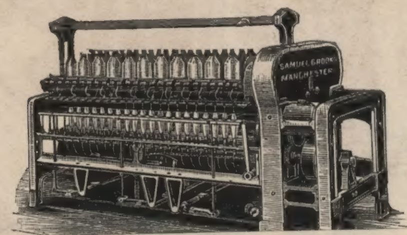

ARTICLE V.—The Library shall be divided into TWO CLASSES; the first comprising such works as, from their rarity or value, should not be lent out, all unbound periodicals, and such text books as ought to be found in a library of reference except when required by Committees of the Institute, or by members or holders of second class stock, who have obtained the sanction of the Committee. The second class shall include those books intended for circulation.

ARTICLE VI.—The Secretary shall have authority to loan to Members and to holders of second class stock, any work belonging to the SECOND CLASS, subject to the following regulations:

Section 1.—No individual shall be permitted to have more than *two books* out at one time, without a written permission, signed by at least two members of the Library Committe; nor shall a book be kept out more than TWO WEEKS; but if no one has applied for it, the former borrower may renew the loan. Should any person have applied for it, the latter shall have the preference.

Section 2.—A FINE OF TEN CENTS PER WEEK shall be exacted for the detention of a book beyond the limited time; and if a book be not returned within three months it shall be deemed lost, and the borrower shall, in addition to his fines, forfeit its value.

Section 3.—Should any book be returned injured, the borrower shall pay for the injury, or replace the book, as the Library Committee may direct; and if one or more books, belonging to a set or sets, be lost, the borrower shall replace them or make full restitution.

ARTICLE VII.—Any person removing from the Hall, without permission from the proper authorities, any book, newspaper or other property in charge of the Library Committee, shall be reported to the Committee, who may inflict any fine not exceeding twenty-five dollars.

ARTICLE VIII.—No member or holder of second class stock, whose annual contribution for the current year shall be unpaid or who is in arrears for fines, shall be entitled to the privileges of the Library or Reading Room.

ARTICLE IX.—If any member or holder of second class stock, shall refuse or neglect to comply with the foregoing rules, it shall be the duty of the Secretary to report him to the Committee on the Library.

ARTICLE X.—Any Member or holder of second class stock, detected in mutilating the newspapers, pamphlets or books belonging to the Institute shall be deprived of his right of membership, and the name of the offender shall be made public.

[SEE NEXT PAGE

SEE NEXT PAGE.


Telegraphic Add
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Nº 6.
COTTON PULLING MACHINE
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VERTICAL CYLINDER
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CARDING ENGINE
FLAT & ROLLER CARD
MILLWRIGHTS AND
BRASS & IRON FOUNDERS
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SINGLE BEATER SCUTCHER
AND
ROVING FRAMES
FLYER THROSTLE FRAME
DRAWING FRAME
LOOMS
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SEE TWO FOLLOWING PAGES.

Machinery for Preparing and Spinning Vigogne and Cotton Waste or Barchant Yarns.

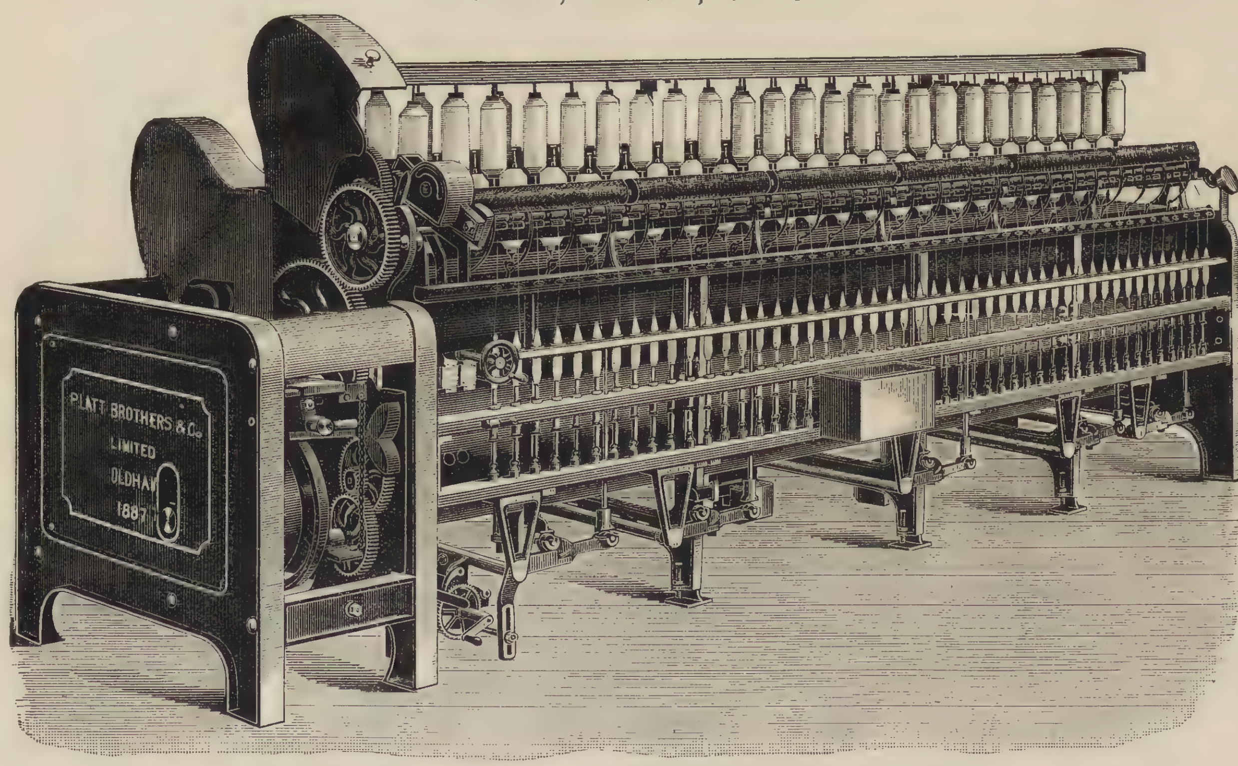
MACHINERY FOR CARDING & SPINNING SILK WASTE.

COMBING MACHINES

For Cotton, Wool, Worsted, and Silk.

DRAWING, SLUBBING, INTERMEDIATE, and ROVING FRAMES,

For Cotton, Worsted, and Silk.



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MAKERS OF MACHINERY FOR

PREPARING, COMBING, SPINNING, DOUBLING & WEAVING COTTON, WOOL, WORSTED, & SILK,

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PATENT MACARTHY ROLLER COTTON GINS, for Long or Short Stapled Cotton.

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PATENT "EXHAUST" OPENERS, with or without Lap Machines, and with Patent Travelling Dirt Lattice applied to Dust Trunk.

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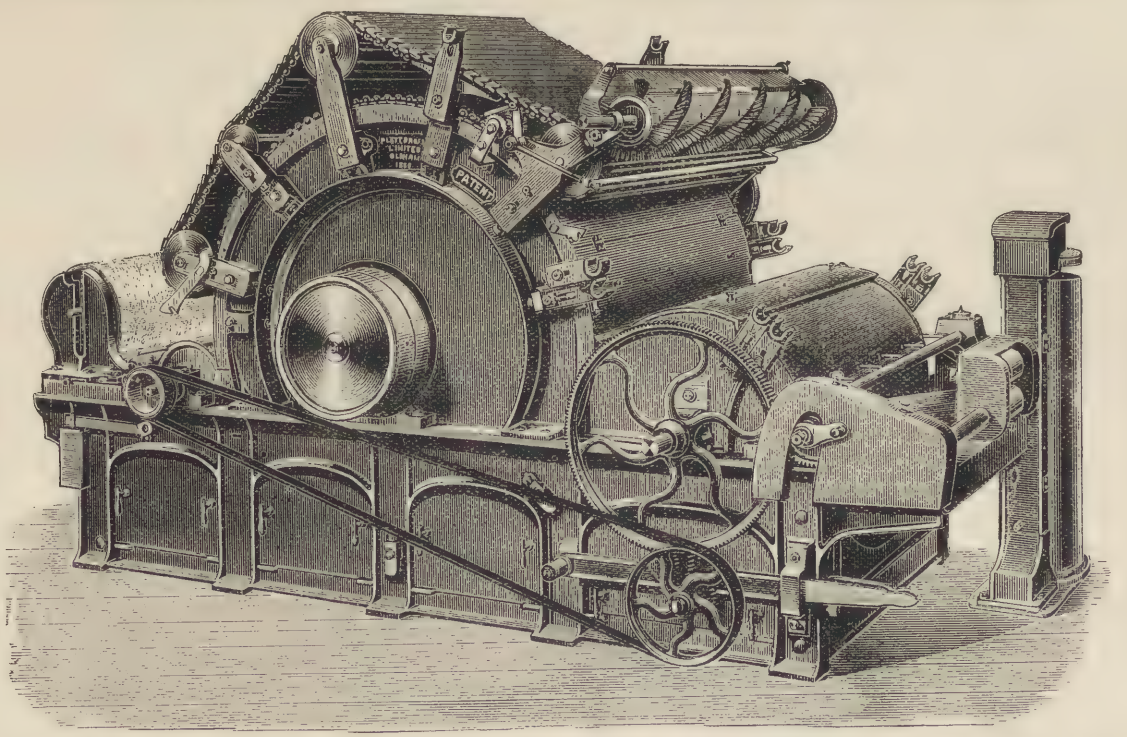

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Of Various Sections, from **72** Flats **2**in. wide, **90** Flats **$1\frac{5}{8}$**in. wide, to **106** Flats **$1\frac{3}{8}$**in. wide.

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ROLLER & CLEARER CARDING ENGINES, Single or Double, made to any width required.

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MODERN COTTON SPINNING MACHINERY,

ITS PRINCIPLES AND CONSTRUCTION.

BY

JOSEPH NASMITH,

ASSOCIATE INSTITUTION MECHANICAL ENGINEERS,

MEMBER MANCHESTER ASSOCIATION OF ENGINEERS, ETC.

WITH TWO HUNDRED AND THIRTY-TWO ILLUSTRATIONS.

MANCHESTER:
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JOHN HEYWOOD, RIDGEFIELD AND DEANSGATE.
LONDON:
E. & F. N. SPON, 125, STRAND; AND 12, CORTLANDT STREET, NEW YORK.
1890.

PREFACE.

IN submitting the following pages to the judgment of the public, the Author does not pretend to have written an exhaustive treatise. This would require a volume much larger than the present. It has rather been his aim to treat a branch of the subject thoroughly, which has hitherto had scant justice done to it. While the market is flooded with books detailing the rules by which speeds are calculated and the necessary wheel changes made, those dealing with the construction of the machinery employed are few in number. This is the more singular, because England is, beyond doubt, the true mother of this department of mechanics, and to-day her textile machinists head the lists alike for excellence of production and fertility of invention.

Since the issue of the late Mr. Evan Leigh's "Science of Modern Cotton Spinning"—comparatively a long time ago—no book has appeared which treats the subject from the machinist's point of view. The well known book of Mr. Richard Marsden, "A Handbook of Cotton Spinning," as its name implies, deals more with the operation than the machinery, although the latter is described in considerable detail. In the present work, while it has been impossible to avoid saying something of spinning, the enunciation of the principles on which the machinery is constructed forms its *raison d'être.* On the Continent, more than one ponderous treatise has been published, which possess the peculiarity of foreign technical works in the disproportionate way in which the small details are treated. While this is valuable from the professorial point of view, it is apt to be prejudicial in actual practice, because the operation of these details varies considerably at different times. The avoidance of pedantry is very essential in any book dealing with practical work, and with this in view, the Author has endeavoured, while fully considering every principle involved, to do so in a plain manner, which will be readily understood. It has rather been the aim to suggest the inferences to be drawn than to dogmatically state inflexible rules.

The whole of the machines have been considered fully, and the most important modifications described. The preparation of the drawings has been a long labour, but the Author believes they have not hitherto been so fully given in any English work. In order to keep the book within bounds, it has been almost rigidly confined to a consideration of the art of textile mechanics as applied to the spinning of cotton to-day. It is believed that the book will provide an accurate account of the state of present knowledge, and will be valuable for that reason.

It should be distinctly understood that the mention of any machinist does not imply any approval or otherwise of his particular appliance, but is simply given in order to identify the maker of it, which it is only fair to do. The Author's opinions can be easily gathered, but it is no part of the scheme to enter into controversy about different methods, or to make the book a treatise on comparative textile mechanics.

The Author desires to thank all those firms who have aided him by the loan of drawings, or in other ways. Without this aid the labour involved would have been largely increased. Thanks are due to Signor Alfredo Galassini and the Director of the Unione Tipografico-Editrice of Turin for permission to reproduce some of the drawings relating to Messrs. Platt Brothers and Co.'s mule, which will be found in Chapter XI. These had appeared in the "Enciclopedia Delle Arti E Industrie," and were so much in accord with the treatment the Author had resolved to give that machine, that the permission to use them was of great service. The special thanks of the Author are also due to Mr. B. A. Dobson for the permission to reproduce two photographs of a lap, given in Chapter VI., and other drawings from his pamphlet on "Carding." In conclusion, before leaving the book to the indulgent judgment of his readers, the Author wishes to say that the proofs have been read by gentlemen conversant with the whole of the details, and every care has been taken to make it at once accurate and instructive.

TABLE OF CONTENTS.

CHAPTER I.

ERRATA.

The reader is requested to make the alterations enumerated below at once in order to prevent any misunderstanding.

On page 51, end of line 23, for "it" read "is."

On page 66, line 15, for "Fig. 51" read "Fig. 52."

On page 162, third line from bottom, for "$n = b - 21$" read "$n = 21 - b$."

On page 163, line 7, for "$n = 250 - 2 (\frac{250}{40})$" read "$n = - 250 - 2 (\frac{250}{40})$."

On page 165, second line from bottom, for "G" read "E."

On page 210, line 3, for "B" read "D."

On page 212, end of last line, for "fallen" read "faller."

On page 267, line 4, for "straps" read "shafts."

The author is fully conscious of many shortcomings, which are inevitable in a task of this magnitude, but he believes that something has been done to formulate present knowledge and practice. Any suggestions of improvements or enlargements will be gratefully received, so as to enable future issues to be more valuable and useful.

enlarging, the possible extent of the cotton industry being enormous. The number of spindles at work in

CHAPTER I.

CHAPTER XIV.

CHAPTER I.

INTRODUCTORY.

(1) The rapid growth of the cotton trade is in no small degree due to the exertions and ingenuity of the engineers and machinists who have devoted themselves to the subject. It is remarkable how few of the later inventions, at any rate, are those of persons actually engaged in the operations of spinning or weaving. It is quite true that James Smith, of Deanston, forms a conspicuous exception, and that many others could be also named who were at once manufacturers and mechanicians, but the general fact is as stated. To-day, the spinner, who is in a difficulty requiring a mechanical solution, turns the whole matter over to the machinist, who puzzles it out without, in many cases, getting his due reward. It is, however, a general practice for machinists to originate improvements, and the competition in this respect is so keen, that a spinner is never at a loss for a choice of appliances.

(2) In the early part of the century it was no uncommon thing to find textile machines made in a workshop where engines, machine tools, and other forms of machinery were also constructed. For about the last forty years this practice has ceased, and it is now the universal custom to make textile machines only, in any works where they are produced. This practice has led to a subdivision, not only of labour, but of procedure, which enables good results to be attained. The machine of to-day, although not absolutely, is comparatively, cheaper, and is constructed in a way that even thirty years ago would have been deemed impossible. When the author was an apprentice, about twenty years since, the fitting of cotton machinery was a byeword to the engineer and tool maker. To-day, it would be difficult to find more accurate workmanship or sounder construction in any machine of whatever kind.

(3) This is a matter of more importance than might be supposed. The cotton spinning machine making trade in England is a very extensive one, finding employment in Lancashire alone for not less than 25,000 men and boys. This does not include the large number of persons employed in the various businesses which are allied to it, such as spindle and card clothing manufactories. The field for spinning machines is ever enlarging, the possible extent of the cotton industry being enormous. The number of spindles at work in Great Britain exceeds 44,000,000; on the Continent the number is about 23,800,000; in the United States 14,500,000; and in India and Japan it exceeds 3,000,000. These figures, which are approximate only, give a grand total of 85,300,000 spindles, which may all be said to have sprung into being during the present century. Assuming the value of a mill to be equal to 21 shillings per spindle in England, the fixed capital embarked in this branch of the trade alone is £44,220,000. If the very moderate amount of 20 per cent be added to this for working capital, the sum invested in cotton spinning concerns in this

country is not less than £53,000,000. The cost per spindle in other countries is much in excess of the amount stated above, being in many cases doubled. In the United States the cost of a fully equipped spinning-mill ranges from 40 to 42 shillings per spindle, and the capital needed for working is also greater than in this country. On the Continent, and in India, the cost per spindle will be less than in America, but the working expenses are also higher than in Great Britain. In thus stating the facts it is impossible to accurately fix the capital employed, but it will probably approach in the aggregate £150,000,000 for spinning mills alone.

(4) The foregoing figures, which are very briefly put, are sufficient to show the magnitude of the industry for which spinning machinists cater. But there is another aspect of the question which is noteworthy, and illustrative of the effect of the work of machine makers. This is the large increase in the productive capacity of the machinery. The production of a self-acting mule in 1835 is given in the following statement, issued by the eminent firm of Sharp, Roberts and Co., and extracted from Dr. Ure's work on "Cotton Spinning."

"Statement of the quantity of Yarn produced on Messrs. Sharp, Roberts & Co.'s self-acting mules in twelve working hours, including the usual stoppages connected with spinning, estimated on the average of upwards of 20 mills :—

No. of yarn.	No. of hanks per spindle. Twist.	Weft.
16's	$4\frac{1}{2}$	$4\frac{7}{8}$
24's	$4\frac{1}{4}$	$4\frac{5}{8}$
32's	4	$4\frac{3}{8}$
40's	$3\frac{3}{4}$	$4\frac{1}{8}$."

This statement is dated December 23rd, 1834, so that it may fairly serve as a basis of comparison, assuming the number of turns of yarn to be in each case the same. Testing the advance by taking the production of 32's, as stated above, the amount spun per spindle in a working week of $50\frac{1}{2}$ hours—its present duration—would be $18\frac{2}{3}$ hanks. Mules at that period were only made 400 to 500 spindles long. To-day they contain over 1,200 spindles, and produce of 32's $32\frac{1}{2}$ hanks per spindle. This is an increase of 60 per cent.

(5) The increase of production has not, however, required a larger number of workpeople to obtain. On the other hand, fewer persons are needed to attend to the long mules named than were formerly required for less than half the number of spindles. The effect of this is seen in the decreased margin between cotton and yarns, which is very striking. The average price of 30's twist yarn in 1832 is stated in Dr. Ure to be 12·7d. per lb., and of cotton 7·1d., leaving a margin of 5·6d. At the time of writing the price of 32's twist is $8\frac{11}{16}$d., and of cotton $6\frac{9}{16}$d. per lb., leaving a margin of $2\frac{1}{8}$d. These figures are based upon the assumption that American cotton of middling quality is used in each case. Thus the price of yarn is much less, while that of cotton is little reduced. It is true that a margin of $2\frac{1}{8}$d. is barely sufficient to permit of a profit being made, but $\frac{1}{8}$d. per lb. added will do so, and a margin of $2\frac{1}{2}$d. is considered a large one in these days.

(6) This reduction in the cost of production has not been brought about by any diminution in the wages of the operatives, as could very clearly be shown if it were necessary. Nor is it the result of a lessened cost of erection. A spinning mill of 40,000 spindles, which in 1835 would be looked upon as a large one, cost, at that time, from 24 to 26 shillings per spindle to erect, including the buildings and accessories. At the present time mills are built to contain as many as 110,000 spindles, and these are filled ready for work at a cost not exceeding 21 shillings per spindle, the apportionment of which is as follows: The machinery costs nine shillings, the buildings eight shillings, and the engines, boilers, furnishings, and all accessories four shillings per spindle. Considering the great increase in the productive power of the machinery, the fact that it is so much less expensive to work, and that each machine is of much greater capacity, the figures given show that the tendency towards diminished cost is owing very largely to the efforts of machine makers.

(7) It is not necessary to pursue this matter further, as the present work is not intended as a statistical abstract, but the few facts stated show that in the general march of improvement the textile mechanic has not been idle. A consideration of the methods of construction adopted to-day, as compared with those in vogue even so recently as twenty years ago, will further demonstrate this fact. Formerly the work of construction was very largely if not mainly carried out by fitters who were engaged in manually shaping the brackets and fitting them to the frames. The brackets were formed with feet, on which were cast nipples or projections. These were used to reduce the labour in filing, and, as the bracket was always fitted on to the face produced in the ordinary operation of casting, it will be seen that anything tending to diminish the work of fitting was valuable. But as the bedding of the brackets was dependent upon the proper shaping of a few points, the tendency to slip was considerable. Although, by being always engaged in fitting a few patterns of brackets, the workmen became extraordinarily expert, the method was at best an uncertain one, and did not lead to the rigidity absolutely essential in high-speed machines.

(8) All this is now changed, and the machine tool enables the work to be at once more expeditiously and economically carried out. The labours of mechanics of precision, like the late Sir Joseph Whitworth, are bearing fruit, and the effect is seen in the comparative excellence of the product. The solidity of English machinery has been sometimes scoffed at by Continental and American rivals, but it would be difficult to find any which runs at higher velocities with greater steadiness and less repairs. It cannot be too often insisted on that the rigidity which arises from mere weight is by no means an unimportant quality. Of course, there are limits to this as to every other principle, but generally it is a true one. Of quite as much importance is the rigidity which comes from sound construction; and in this respect modern spinning machinery is remarkable. Instead of a framing built up by hand with its various pieces manually fitted, it is now made in a much more enduring way. Raised faces are formed on the framing, which are planed or milled, so as to be quite true. To these the cross-beams or bars, the ends of which are similarly treated, are bolted. Thus, instead of the contact of several narrow faces, two broad plane surfaces are bolted together, and it will be easily seen how much more solid the framing will be in consequence. Again, in lieu of each part being at once like and unlike, as must necessarily happen when it is hand-fitted, it is now shaped by special machinery to templates, thus being interchangeable. The rails or beams to which bearings,

brackets, or spindles are to be attached are planed or milled accurately on their surfaces, so that the long and unsatisfactory labour of fitting each piece separately is substituted by a true mechanical process. The advent of the milling machine and the discovery of the wonderful economic power of the circular cutter has had a wide-reaching influence. In brief, the present is an age of an increased development of machine instead of manual treatment, which has gone far to revolutionise the machinery used in spinning. Every student who may hereafter be engaged in the construction of this class of machinery should impress firmly upon his mind the fact that the machine tool is the best instrument for his purpose, and should develop it as far as possible. A special tool is invaluable, and the opportunities for its use are always increasing.

(9) A comparison of the speeds of various machines will demonstrate the value of improved construction. Mule spindles, which in 1834 were run at a maximum velocity of 4,500 revolutions per minute, are now revolved 11,000 times per minute with much greater ease and freedom from vibration. The throstle spindles running at a speed of 4,500 revolutions, are superseded by ring spindles, which rotate from 9,000 to 11,000 times per minute. As shown in Chapter XII, it would be impossible to attain such a velocity unless the spindles were accurately constructed by special tools. Although the mechanism of a ring spindle is much more elaborate than that of a throstle spindle, the cost of the one but little exceeds that of the other. Again, a carding engine cylinder, formerly made of wood, and running 80 to 100 revolutions, is now constructed entirely of iron, and revolved at from 160 to 180 times per minnte. In spite of this increase it is more free from vibration than its slower running predecessor. A similar comparison can be made of every machine with like results, but it is not necessary. Enough has been said to show the important part played by the machinist, to whom, as was pointed out in paragraph 1, most of the credit is due. The economical improvement which is noticeable in the condition of the workpeople is largely the result of the improvements made in the machinery. In fewer hours more work can be turned out, and this with a constantly decreasing strain upon the operatives. The breakage of the fibres in the various stages of manufacture is reduced to a very low point, with the two-fold advantage of diminished waste and decreased labour.

(10) A modern mill differs from its immediate predecessor, not only in the quality of the machinery but in its general construction. The height and width of the whole building have materially increased, and the result is that the rooms in which the operations of spinning are conducted are both lighter and more airy. The building is usually made as far as possible fire-proof, and is of very substantial design and construction. The larger number of spindles in a mill necessarily imply greater capacity, but there is no comparison between the low-ceilinged, imperfectly lighted and ventilated rooms of the last generation with the airy and light erections of to-day. The sanitary arrangements are infinitely superior, and there is a noticeable improvement in the health and physique of the workpeople arising therefrom.

(11) Among the features which deserve mention is the improved type of engines used. In lieu of the old-fashioned beam engine, compounded or otherwise, working at a steam pressure of 50lb. or less, the modern engine is of the horizontal type. The favourite class for mill driving is the tandem compound, in which the high pressure cylinder is behind the low-pressure, but on the same bed. Latterly the vertical triple expansion engine has been adopted in a few cases, and there is a continual tendency towards higher steam pressures and more

expansions. The introduction of steel boiler plates has rendered the construction of steam boilers for high pressures much more easy, and the author has seen a Lancashire boiler, intended for habitual use at a pressure of 220lb., tested with highly satisfactory results. Within limits, therefore, there is room for a further increase from the normal working pressure of 80lb. The steam-engines used are mostly of the Corliss type, with quick cut-off gear of high efficiency, and they are constructed to develop in many cases from 1,000 to 2,000 horse-power. The water used for condensing purposes is stored in reservoirs or "lodges," from which it is drawn as required. It is sometimes difficult to cool it sufficiently to get a good vacuum, owing to the fact that the cooling and storage space is insufficient. For this purpose a type of condenser known as Theisen's, which has been largely adopted in Germany and is now being introduced into this country, will be of value. It is arranged as a surface condenser, the steam passing through the tubes and being cooled by water surrounding them. In lieu of giving the water a circulatory movement it always remains in one position, any loss by evaporation being replaced. Between each vertical row of pipes cast-iron discs revolve, which are fixed on a shaft suitably driven. As each disc dips into the water—which is usually about 160 deg. F.—it picks up a thin film and carries it round in its revolution. At the upper part of the case, in which the discs revolve, an air propeller is fixed, which sends a current of air past and through the spaces between the discs. This leads to a rapid cooling of the disc and its water film, the heat absorbed by the water being in this way dissipated. The action is one of evaporative cooling, of which many instances abound, and is very effective. An equal weight of water will effectually condense any given volume of steam, and this quantity is not difficult to find in most places. The results obtained by the Union Engineering Company in this country have been satisfactory, and there appears to be no doubt as to the efficacy of the machine. Steadiness of rotation is a *sine qua non* in mill engines, a very slight difference in their velocity having a great effect upon the work of the mill. This is now attained in most cases with certainty, and by means of the Moscrop Recorder—an instrument denoting graphically the changes of speed—a very salutary check is kept upon the engineer. In order to prevent any variations occurring high-speed governors are largely employed, and in some cases their action is aided by special means, such as Knowles's supplementary governor or Higginson's patent regulator. Either of these appliances give good results, and the last named is very simple and effective.

(12) Up to within 15 or 20 years ago the most common mode of transmitting the power developed by the steam engine was by means of toothed gearing. About that period the American method of driving by a series of broad belts was introduced and for a time was largely adopted. When toothed gearing was used the power was conveyed to the various flats or storeys of the mill by means of an upright shaft, on which were bevel wheels gearing with others on the line shafts. The introduction of belt driving led to a system of transmitting the power to the main shaft in each room independently of its fellows, and this system found further development when driving by a series of ropes was adopted a short time afterwards. In this case the power is taken off by a number of ropes working in the grooves of a large pulley on the engine shaft and of smaller ones fixed on the line shafts. This is now the favourite method of driving and is more extensively adopted than any other. The reason for this is principally the ease with which breakdowns can be guarded against. If a rope breaks it falls into the race, and

in rare instances does it become entangled. It is only necessary to replace it, and any delay thus caused is not great.

(13) As the question of driving is a somewhat important one a few remarks may be made on it. There is no doubt that toothed gearing properly constructed forms the most economical method, the loss of power in transmission not exceeding $2\frac{1}{2}$ per cent. In constructing wheels for this purpose care should be taken that the tooth is not too long, $\frac{5}{8}$ths of the pitch being a sufficient length. Next to toothed wheels for economy belts may be placed. The loss in transmission varies, if the belts are properly applied, from three to five per cent. A good speed for leather belts is 3,000 feet per minute if they are single, and 4,000 feet if double. Rope driving is the least economical of the three methods, this arising from a variety of causes. Chief among these is the difficulty of maintaining an equal diameter in every rope of the series, which leads to a difference in their driving power, owing to their unequal engagement with the V grooves. Another cause of this loss of power is found in the fact that they jam in the grooves and have to be forcibly extracted as the pulleys revolve. The following rules laid down by Mr. Alexander Rea in a discussion, at a meeting of the Manchester Association of Engineers, on the subject of the comparative merits of the three systems of driving, are worth reproducing.

"The ropes should not be too large in diameter; it is much safer to use 25 $1\frac{3}{4}$ inch ropes than 20 2 inch diameter ropes. The tension in the several ropes should be kept as low as possible. The power should be subdivided to different points. The centres of the several shafts should be kept well apart. The pulleys should be large in diameter. The best speed for the ropes is from 4,000 to 6,000 feet per minute. Care should be taken in turning the V groove pulleys; the best angle for these is now found to be 45 degrees."

(14) As this subject of rope driving is an interesting one, it is worth noting that Mr. George Goodfellow, of Hyde, who has had a wide experience in this matter, confirms the advice as to small diameter of ropes. In the same discussion he stated that he did not now use larger diameters than $1\frac{3}{4}$ inch, and had ropes running successfully, the diameter of which was only $1\frac{1}{4}$ inches. Mr. James Hartley also bore out this experience. By the reduction of ropes from 2 inches to $1\frac{1}{4}$ inches diameter the friction diagram from the engine had been materially reduced, indicating a saving of power. Mr. J. H. Ratcliffe, of Dukinfield, has recently revived a method by which, instead of using a series of ropes, he uses one only, this being endless, and being wrapped spirally on the pulleys. At one point the slack is taken up by a compensating apparatus, so that the whole of the coils are tight back and front instead of having one side slack and bellying. For this arrangement Mr. Ratcliffe claims that it materially reduces the friction diagram, inasmuch as there is no necessity to drag the rope forcibly out of the grooves at each revolution. It is not necessary for a detailed examination of this subject to be made, bu the hints given will probably prove useful to many readers.

(15) It is essential, owing to the peculiar structure of the cotton fibre, to which reference will be made in the next chapter, that the rooms in which spinning is conducted should be heated to a certain temperature. Closely allied to this question is that of humidification. It is not only essential to have heat, but that must be accompanied by a certain amount of moisture, a point which is often neglected. Spinning rooms are often heated

to over 90° F., which is quite unnecessary, and is, moreover, detrimental to good work. At such a temperature much of the natural moisture of the cotton is extracted, and the fibre becomes harsh and brittle. A temperature of from 75° to 80° F., with a humidity of about 75 per cent, is absolutely the best condition for spinning. The question is an important one, and deserves greater consideration at the hands of spinners. The artificial heat required is now obtained by the use of wrought-iron steam pipes, through which high-pressure steam is passed. The radiation from these is much greater than from cast-iron pipes of larger diameter filled with low-pressure steam.

(16) Having thus briefly glanced at some of the chief features of modern practice, it is now only necessary to say that the utmost cleanliness is absolutely essential to good working. The manipulation of the cotton is now so largely automatically performed that there is much less difficulty in keeping a mill clean than formerly. It should be the aim of every spinner to diminish the handling of the material as much as possible, and students of this subject should remember that it is never too early to begin to deal with the cotton so as to prepare it for subsequent treatment. Efficient purification at an early stage is a great help towards economical and efficient spinning. In conclusion, it may be remarked that one of the worst faults in studying a subject of this sort is any kind of crystallised thought. The conditions of work vary from day to day, and there are wise variations in procedure which can easily be discovered by the observant mind. This watchful attitude is the proper one to cultivate, and the succeeding pages are written in the hope that they will lead some reader to a deeper and closer observation of the facts which are discoverable in the actual work of construction or spinning.

CHAPTER II.

THE STRUCTURE OF COTTON.

(17) The cotton plant is indigenous to many tropical countries, in which it is often found in a wild state. The product of the wild plant is, however, quite unsuitable for manufacturing purposes, and, even in cases where cotton is produced by cultivation, the value of the fibre varies very largely. Into the question of the growth and structure of the fibre it is not necessary to go in detail, as this is a subject which has a literature of its own. The student who is desirous of obtaining a thorough knowledge of the subject can find it fully treated in the "Structure of the Cotton Fibre," by Dr. Bowman, and in a recent work by Mr. Hugh Monie, jun., of Glasgow. It will suffice for present purposes to state briefly the characteristics of cotton, which are of essential importance in its subsequent treatment mechanically. The cotton fibre is a hollow tube of cellular construction, and is of an oval or flattened cylindrical shape. Ripe or fully matured fibres of the best cotton are convoluted or spirally twisted on their axis, and the edge of such a fibre presents a corrugated appearance. The regularity of the convolutions, or twists, is greatest in the highest class of cotton, and reaches its lowest point in the poorer grades. One important effect of such a formation is that each fibre naturally tends to coil round its neighbour, and thus lends itself to spinning. The outer sheath of each fibre is apparently continuous, and the diameter is greater at the end which is attached to the seed. The diameter of the fibre varies from $\frac{1}{1562}$ of an inch in the case of Sea Island cotton, to $\frac{1}{1185}$ of an inch in Indian cotton. In length a similar variation is observable, reaching a mean of 1·8 inch in Sea Island, and being as low as 0·8 inch in Indian cotton. The length of the fibres in any particular class of cotton is known as the "staple," and this is one of the chief commercial merits of the better kinds. The strength of cotton fibres varies very materially, and on the authority of Mr. Charles O'Neill, of Manchester, the order in which the various classes ought to be placed is as follows:—Surat (Comptah), New Orleans, Queensland, Surat (Dhollerah), Pernambuco, Egyptian, Maranham, Upland, Sea Island. It does not necessarily follow that the possession of greater strength by one class of fibre over another involves an advantage, for the greatest strength is possessed by a fibre which is the most deficient in regularity of the convolute form and length, which are much more important than strength. Again, the diameter of Comptah cotton is much greater than that of longer stapled varieties, and this is important in determining the value to be placed upon the strength. Viewed in this light, Egyptian cotton is the strongest, and this fact, in conjunction with certain other qualities to which attention will afterwards be called, renders it of high value. It only remains to be said that a waxy covering is found on the outside of each fibre, which requires to be softened by heat during spinning so that the flexibility of the fibre may be fully maintained. Where it is intended to dye fabrics it is necessary to remove the whole or the greater part of this wax, and so permit the dye to penetrate the fibre. Having briefly indicated the chief characteristics of the cotton fibre, a detailed account of some of the principal varieties may now be given.

(18) Sea Island Cotton. This is the finest class of cotton produced, being long in the staple, very flexible, and having very regular convolutions. If care be taken in ginning, so that the fibre is not broken, the finest yarns can be produced from this variety. The length of Sea Island Cotton is stated by Dr. Bowman to reach 2·20 inches in the case of Florida grown, but Mr. Monie states the average length to be 1·8 inches. Mr. Evan Leigh confirms the higher length, but only in the case of cotton grown on the Edisto Island. Varieties of this grade are grown in Peru, Fiji, and Australia, the average lengths being respectively 1·56, 1·87, 1·65 inches. Fijian Sea Island is spoiled by bad ginning, which breaks the fibres very much. The colour of Sea Island cotton is a light creamy one, and is peculiar to it.

(19) Egyptian Cotton. Egyptian cotton varies considerably in colour, length, and quality. The variety known as Gallini is of a golden colour, the fibres being tough and strong, and the convulutions very regular. It has a mean length of 1·5 inch. Brown Egyptian is, as its name implies, of that colour, and like Gallini, the fibres are strong and tough, but are coarser, the convolutions are less regular, and the wall of the fibre is also denser. The mean length is 1·4 inch and the diameter $\frac{1}{1325}$ inch. White Egyptian is, perhaps, the most valuable of all this class of cotton when properly treated. It is of a light gold colour, the fibres being strong and pliable, but only partially spiral. As a result of this, the yarn spun is greater in diameter than that spun from Gallini (weights being equal), the fibres not lying so closely together. This cotton mixes well with American and Brazilian.

(20) Brazilian and Peruvian Cotton. Pernambuco cotton is of a slightly golden colour, and is, comparatively speaking, hard and wiry, being thus well adapted for twist yarn. The twists in the fibre are well developed, and the average length is 1·25 inch. Maranham is of a dull gold colour, mixing well with American cotton. There are several other varieties of Brazilian cotton, which need not be further referred to. Rough Peruvian cotton is very clean, of a creamy colour, and is possessed of an average strength. The fibres are only irregularly twisted, and an average length is 1·3 inch. The smooth variety is fairly regularly convoluted, and mixes well with Orleans.

(21) American. There are several varieties of American cotton, which are grown in the Southern States. Taking them in their order as regards length of staple, the first to notice is Orleans. The better classes of this are very uniform in length, clean and light in colour, often being pure white. One feature of Orleans cotton which renders it very acceptable to spinners, is that it is very flexible, and possessed of a high elasticity. In addition to this, as has been previously noted, its strength is fairly great, and generally its spiral form is well developed. The average length is about 1 inch. Texas cotton is less pliable than Orleans, darker in colour, and is not put on the market so free from immature fibre. Its diameter is greater, and its average length about equal to Orleans. Upland cotton is clean, and little waste is produced from it. The fibres are well suited for weft yarns, being soft and elastic, and of a very light colour. Spun without any admixture of other cotton, yarns as high as 425's can be produced, but when mixed with Egyptian or some other strong fibre, higher counts can be obtained. Mobile is similar in colour to Orleans, and is equal to Uplands in strength. It is not so good as either of these for manufacturing purposes, being much dirtier, and having more flattened fibres in it.

(22) Indian. The whole of the cottons grown in India are less valuable than the preceding varieties, owing to the facts that they are not so regularly spiral, and that the staple is more variable. The highest class is

Hingunghat, which is more convolute than any other Indian grown cotton. The fibres vary in diameter, but have an average length of 1·03 inch. Broach is brownish gold in colour and is fairly clean, although it is not thoroughly cleaned, and contains a good deal of leaf and nep. It is about 0·9 inch long, and is more regular in this respect than Hingunghat. The spirals are fewer in number, and it is stated by Mr. Monie that the walls are very liable to rupture. Dhollerah is of a white colour, and is best adapted for weft yarn. Oomrawuttee is creamy in colour, being strong but rather short in the staple. A good deal of impurity is found in this quality, but the convolute form is moderately developed. Tinnivelly is grown in the Madras Presidency, and is a fairly good cotton. In strength it is high and is very elastic, its colour being a dull, creamy one. The fibres have a small bore and thick walls, and are, in addition, only slightly twisted. The worst Indian fibre is Bengal, which is short, strong, and dirty.

(23) Commercial qualities. The recapitulation of the principal features of various growths of cotton just given enables their relative value for spinning to be pointed out, and at the same time to indicate the qualities it is desirable to retain during the subsequent mechanical treatment. Sea Island cotton is beyond doubt the finest quality existing, and, in the manufacture of fine counts, is absolutely essential. Its general excellence is undoubtedly attributable to the conditions under which it is grown, and even this might be improved by more careful cultivation. Egyptian cotton is also of great value in the production of good yarns, and is very largely used for this purpose. Owing to the existence of a number of short fibres, always found in commercial quantities, but present here in larger proportion, it is necessary to comb all Egyptian cotton. The chief advantage of its use is that being relatively stronger, smoother surfaced, and more flexible than qualities other than Sea Island, a large range of yarns for various uses can be spun at a price which enables them to be profitably used. The fibres are very regular in diameter, and when twisted lie very close together. The most widely used cotton is, however, the various brands of American, which have the advantage of careful attention during their growth and collection. In consequence of this, there is a very high uniformity attained, together with great freedom from all sorts of impurities, these two qualities rendering American cotton highly suited for general use. Indian cotton is coarser, harsher, and not so clean as other varieties, and requires greater care in its manufacture. Summing up, the desirable points in cotton are the length and regular convolute form of the fibre, together with its freedom from mechanical and chemical impurities. The object of the earlier mechanical processes through which cotton passes is to remove all the impurities, lay the fibres regularly and in equal numbers alongside each other, without breaking or rupturing them, and without destroying their natural tendency to twist round each other. In doing this, not merely do the seeds, leaf, and sand require removal, but also the short immature fibres which form into little knots or tangles called "neps." Great care is needed in the preparatory stages so as to avoid damage, and it is especially necessary to avoid the removal of the waxy sheath which plays an important part in the manufacture of the fibre. The necessity for a warm, humid atmosphere has already been referred to, but it may be noted that it is very important on account of its softening effect upon the waxy sheath. If the latter be removed the heat becomes a source of difficulty instead of a help, as the natural moisture existing in the fibre is more speedily absorbed.

CHAPTER III.

GINNING AND MIXING MACHINES.

(24) When the cotton is ready for harvesting it is picked from the shrubs by hand. There have been many attempts to pick it by machinery, but these have not hitherto been very successful. After picking, it is subjected to the action of a machine called a "gin," which is sometimes arranged to be worked by hand, but more often by power. In the latter case the machines are placed in a shed, and the cotton is brought there for treatment. The object of ginning is to remove from the cotton the seeds, which adhere closely to the fibre, and which have of late years acquired considerable value for oil-producing purposes. In order to remove them it is necessary that the fibre should be held in some way while it is submitted to a rubbing or scraping action, by which the seed is separated. To effectually perform this function great care is required, as otherwise a quantity of the seed is broken, and the fibres are rubbed up into "neps." If either of these effects is produced additional labour is thrown on the spinner in his subsequent treatment, and it is therefore desirable to avoid such a manipulation of the machine as would lead to so undesirable a result.

(25) In Figs. 1 and 2 a single Macarthy gin is illustrated in part sectional side elevation and front elevation. This is a type which, in principle, is now largely adopted. It consists of a roller A, rotated in the direction shown by the arrow, by means of a strap passing over a pulley fixed on the end of the roller shaft. The latter is square, and is passed through the centre of the roller, fitting a corresponding hole in the latter, and being carried by suitable bearings fixed on the machine frame. In constructing the roller A the following method is adopted. Wood segments are fitted together so as to form the complete cylinder, or the latter may be made in one piece. Having produced the body, it is fixed on the shaft, and is then turned quite round and parallel. Upon the surface so prepared a thick covering of walrus leather B is fixed, in which spiral grooves are formed. The rough surface of the leather, as the roller is revolving, seizes the cotton fibres as they are fed along the table F, which has a grid G at its inner end, a special feed being sometimes fitted. When the fibres are drawn in by the roller they are taken under a knife blade C, which is fixed above the roller by means of the sets of clamps D and E. The clamps D bind the blade to its bearings, and those marked E are used to regulate its pressure on the roller A. As the roller occasionally becomes hollow the wisdom of this procedure will be seen. A crank shaft is placed and driven from the shaft of the roller, and gives a rapid reciprocating motion to a connecting rod I, which has at its upper end a blade H. The height of the blade H is regulated by means of the adjustment of the connecting rod strap, to which it is jointed, and which can be packed to any desired amount. The blade is coupled to radius arms J, adjustable by nuts at their outer ends, and oscillating on a rod fixed below the feed-table.

(26) As the fibres are drawn under the upper blade C, the lower blade H pushes up the seeds, which cannot pass between the roller and the blade C. In this way the seeds are freed from the fibre, which is carried forward

and thrown off at the front of the machine, or it may be stripped by a fixed blade. The setting of the blades C and H should be arranged so that the necessary pressure is applied to the seeds to free them, but care must be taken that the lower blade does not rise so high as to crush them. It should also be set relatively to the roller, so as not to roll up the fibre by having close contact with either the roller or upper blade, while effectually removing the seeds. Other forms of ginning machines are made, including one in which rollers formed of a number of saws are employed, but their use is not so large as that of the Macarthy machine, which may be taken as typical.

(27) After the cotton is ginned, it is pressed in large hydraulic presses into bales of various sizes and weights, ranging from 400 to 600lbs. each. In this form it is imported into this country, and delivered to the mill-owners. The purchases of the material are made from samples of a few pounds taken from one or two bales of a lot of the same brand, and it is essential in purchasing that not only the "staple" but the condition

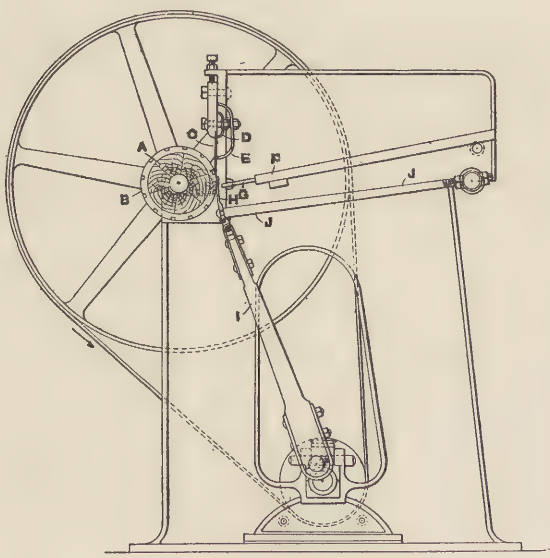


Fig. 1.

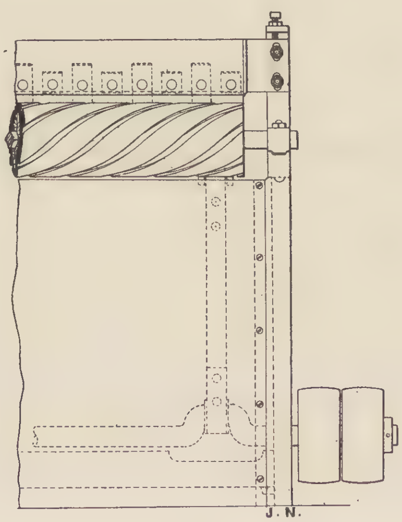


Fig. 2.

in which the cotton is packed should be taken into account. In some seasons the percentage of moisture is much higher than in others, and in wet seasons a large weight of adherent sand is certain to be found. This, indeed, is the case always, but it is much greater after a bad season than when the weather is normal during picking. The question of the delivered condition of the fibre is a very sore one commercially, as it results in serious loss to the millowner, and there is little doubt that in many cases a fraudulent intermixture of sand is made.

(28) Whatever may be the condition in which the cotton is received, the first operation at the mill is to open out the bale and break it up into pieces of a convenient size. For many years this was conducted purely as a manual operation, but an arrangement which was made by Messrs. Platt Bros. and Co., in 1855, and has been working ever since, is shown in Fig. 3. This consists of a lattice feed table F, which delivers the cotton and brings it into the range of action of an opener cylinder C. The latter opened the material to a considerable extent,

and threw it on to a second lattice H, by which it was delivered to a third one, and conveyed to the mixing stacks in a manner to be afterwards described. The operation is now almost always carried out by a machine known as a "bale breaker," a perspective view of which, as made by Messrs. Platt Bros. and Co. Limited, is shown in Fig. 4.

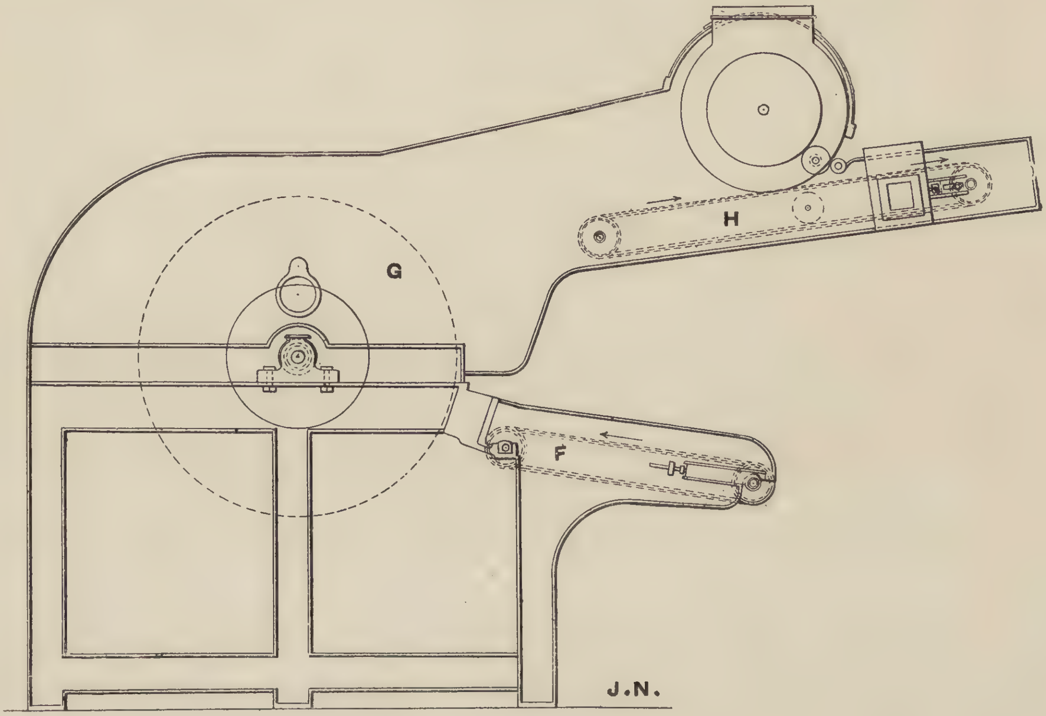


FIG. 3.

It consists of a feed table, placed between the projecting framework, and is usually of the lattice type. The lattice feed apron consists of a number of narrow strips of wood fixed to two endless bands passing round rollers at each end of a longitudinal frame fixed to the machine. By suitably driving one or both of the rollers a continuous

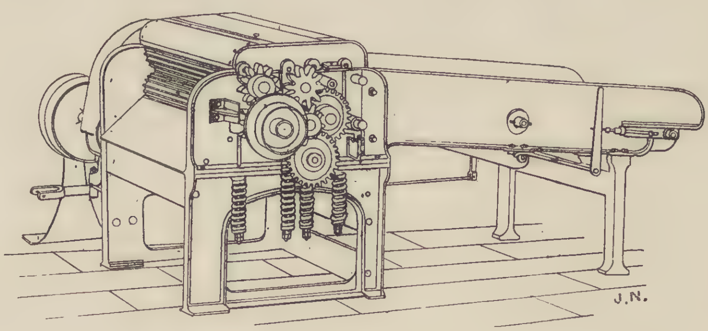


FIG 4.

motion is obtained, and the wood strips being each free from the other no difficulty is experienced in forming an endless apron or feed table. The cotton is placed upon the table in large pieces or lumps, just as these are taken from the bale, and they are carried forward until they come into contact with the first pair of rollers. There are

usually four pairs of rollers driven by means of the spur pinions shown in the illustrations. The first pair are provided with coarsely-pitched blunt teeth or spikes, which seize the cotton and pass it onward to the next pair, which are of similar construction. The last pair of rollers are usually made with coarse, longitudinal corrugations, or flutes, as shown in Fig. 4, which deliver the cotton either on to the floor of the room, or on to lattice aprons arranged as hereafter noted. The top rollers are weighted by helical springs in the manner shown, and can easily yield if any obstruction or unusually large piece of material passes between them. The speed of the rollers increases rapidly, but there is a divergence of opinion as to the proportion of increase over the whole series. It will be well, therefore, at this point to state the conditions of the case fully.

(29) Before doing so, however, it is necessary to explain a term which even at this early stage is used, and which is a common one throughout the whole series of operations constituting spinning. The variation in the speed of the rollers of the bale breaker is known as its "draught." In other words, an elongation or enlargement of the bulk of the cotton occurs in exact proportion to the velocity of the rollers. Thus, if the relative speed of the first and last of the series of rollers is as 1 : 30, the draught of the machine is the same. In the case of the bale breaker the draught results merely in an increase in the bulk of the cotton, but subsequently it leads to an elongation of the sheet or sliver into which it is formed.

(30) It being highly desirable that the naturally open fleecy condition of the cotton shall be restored at the earliest moment, the question arises, What shall be the draught of the bale breaker rollers? Is it necessary to do more than break up the lumps of cotton into smaller pieces, which can be readily treated by the subsequent machines? To these questions different answers are given. On the one hand, it is contended that what is required is to reproduce the conditions of hand breaking, by which the cotton was pulled from the bales in small tufts ready for delivery to the opening machinery. Another practice advocated is to so pull the lumps into which the bale is broken up that the cotton when delivered is in an open fleecy condition. It would be preferred by spinners if they could obtain the cotton in the loosely packed condition in which it is received by the Indian spinners, for instance. As this cannot be done, owing to commercial and transit considerations, the question arises whether the first stage in the processes conducted in this country is not the right one to restore this condition.

(31) Between the two positions formulated there is a wide divergence, but, to the author, the latter appears to possess the balance of advantage. There can be no doubt that the preparation of the fibre cannot be commenced at too early a stage, and, as efficient cleansing is one of the first objects to be attained, it follows that the earlier the open condition of the cotton is reached the more readily can cleaning be effected. It must not be forgotten that care is necessary to avoid possible damage to the fibres, but, with rollers properly speeded, there appears to be no reason to expect such a result.

(32) In consequence of the divergent views held, the draught of a bale breaker varies considerably. In some cases it is only 2 : 1, while in others it reaches 30 : 1. The former is the rule adopted by Messrs. Crighton and Sons, who advocate the first course named, and the latter that adopted by Messrs. Lord Brothers, who prefer the second. Messrs. Platt Brothers and Company recommend a wise variation in this respect, proceeding upon the

principle that different staples require different treatment. Thus one machine made by them has four rollers with a large draught, this being used for good staples, and producing as much as 90,000lbs. weight in 50 hours. In dealing with Surat cotton, which is more hardly pressed, two sets of rollers are used, followed by a beating cylinder by which the cotton is thoroughly broken up (Fig. 8). In each case it is customary to attach lattices to the machine, by which the cotton is carried forward and deposited in the mixing bins (E Fig. 13). (See also Figs. 6, 7, and 8). Another method is to treat Surat cotton by first passing it through breaker rollers, and thence through a Crighton cylinder, described in Chapter IV. The bale breaker may in this case be used either singly or as part of the combination.

(33) The rollers are made in two ways. They are cast in one piece and are mounted upon the shaft; or are built up from a number of discs threaded and fastened upon the shaft and bolted together. The latter is the preferable course, the breakage of a few teeth being easily remedied.

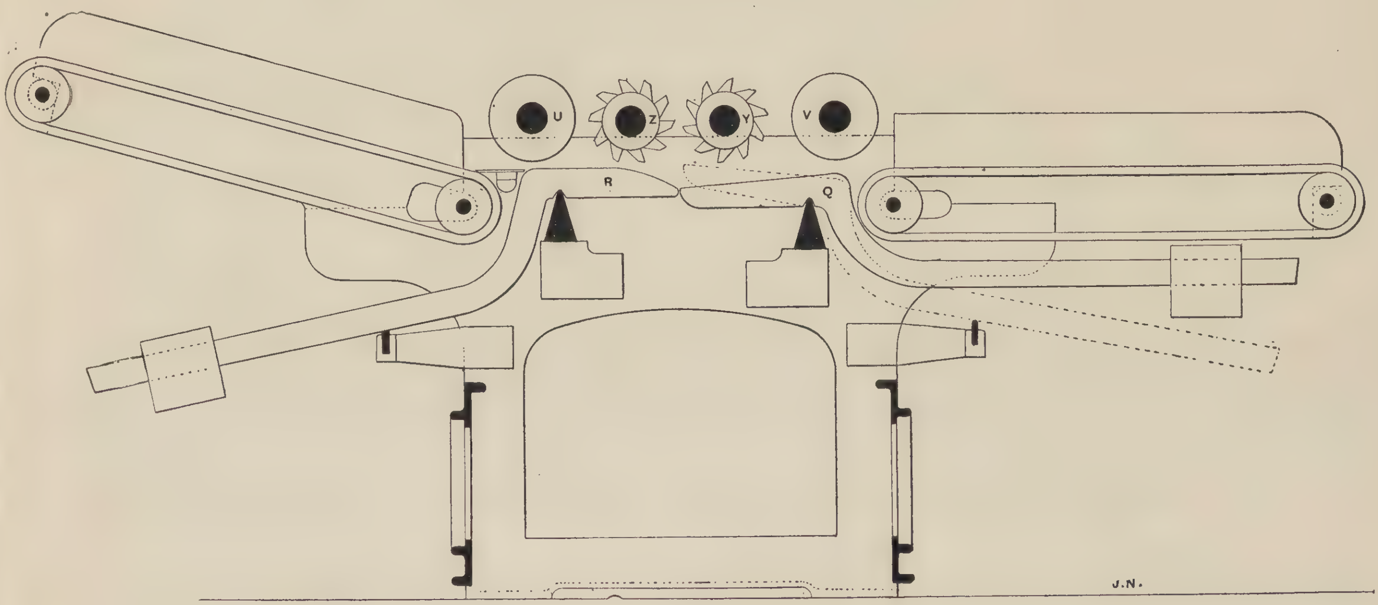


Fig. 5.

(34) Before proceeding further, reference may be made to Fig. 5, which is a transverse section of the machine as made by Messrs. Dobson and Barlow. The top rollers of the machine, as ordinarily made, are provided with spring weighting, in order to permit them to rise if an unusually large piece of cotton is passed between them. If this enters at one side of the machine it will be at once seen that the roller will be raised at that side, and that its axis will be angularly disposed to that of the bottom roller. The two rollers will only be near each other at one side, and between them, across the whole of the width of the machine, will be a gradually increasing space through which lumps of cotton can pass unpulled. This is a defect of more or less magnitude, but is one which is ingeniously remedied in the machine shown in Fig. 5. Only one line of rollers, marked U V Y Z, is used,

by two of which the pulling is effected. Below these the noses of iron bars or levers, Q R, fulcrumed on knife edges, are placed. The bars are a few inches wide, and extend below the rollers over their entire width. The cotton passes over these "pedal" levers, which are weighted at their other end, and yield, as shown by the dotted lines, when an extra large piece of cotton passes. The weight is sufficient to enable the cotton to be held until it is pulled by the roller. It will be at once seen that only the pedals affected by the lump will be depressed, the remainder occupying their normal relative position to the roller, which is fixed by the stop shown. In this way the presence of a thick piece at one point in the width of the rollers does not affect the pulling at another point.

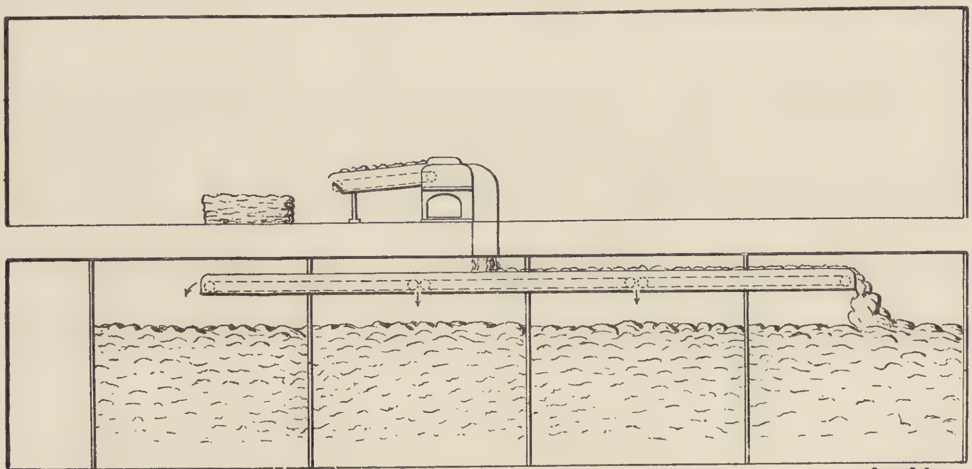


Fig. 6.

(35) The cotton being pulled, it is necessary to mix it. This is effected by delivering it upon a second lattice, B Fig. 13, which can be made of any desired length, and by which the cotton can be delivered on to a third lattice C running transversely or in any other direction. Three such arrangements—the sketches supplied by Messrs.

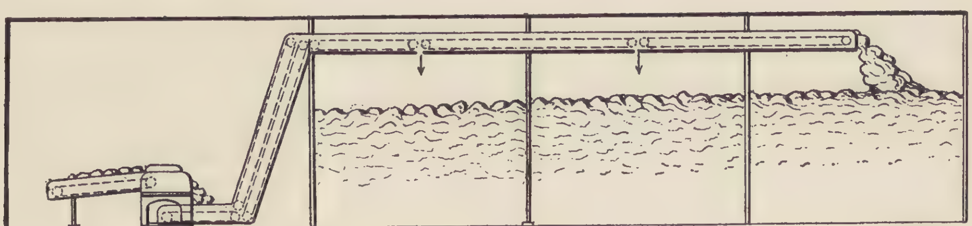


Fig. 7.

Platt Bros. and Company—are shown in Figs. 6, 7, and 8, but there is practically no limit to them. By means of these devices as much as 90,000lbs. weight can be laid down per week by two workmen. To avoid the risk of fire, the flutes are so arranged as not to come into contact, but it is advisable to place the machine in a building removed, if possible, from the main structure.

(36) Having broken up the bale as described, the cotton is in a condition to be mixed. This operation is one of the most important in the economy of a cotton mill, and on its judicious and thorough accomplishment depends very often the production of a profit or loss. In order to obtain the best possible yarn the longest-stapled cotton should be used, and should be selected so that the fibres, when spun, are as nearly as possible of one length. By careful selection a practically perfect yarn can be produced, but it would naturally be a dear one. It is, however, possible to apply the same principle in the production of cheaper qualities of yarn. Briefly stated, the principle is, that to spin a good yarn it is necessary to use cotton in which the fibres are of approximately the same length The longer the "staple" of the cotton the better the yarn; but, even when short staples are used, this selection is still essential to success. This does not necessarily mean that the same grade of cotton should be used exclusively, but, on the contrary, several can be mixed, provided that the staples are equal, even if they are not of the same commercial value, and differ in other characteristics. By a careful selection of cotton a mixture can be obtained from which a good even yarn of fair strength can be spun, the cost of which would be lower than it would be if a single good grade only was used.

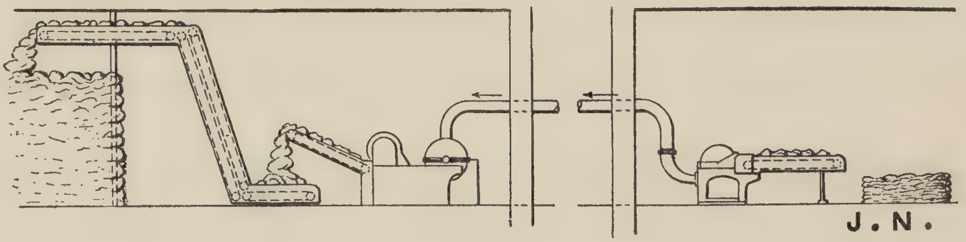


FIG. 8.

(37) It is the practice in making a mixing to place round the breaker bales of the various grades which are to compose it. The attendant takes a layer from each bale in succession, and places it on the feed lattice of the bale breaker, by which it is broken and partially mixed, so that when stacked the elements of the mixing are well incorporated. The size of the stack depends very largely on the requirements of the spinner, but as most mills now are employed on a small range of counts, some of them on one or two, it is most usual to make a large one containing sufficient cotton to last for several weeks. By pursuing this course there is a very much better chance of getting a regular quality of yarn, which is essential to the commercial success of the mill. In taking cotton from the heap it is the best plan to begin at the top of the face and work downwards in a straight line, as by this procedure a uniform quantity of the different elements in the mixing is obtained. It is desirable to make a small stack of the same classes of cotton as the larger one is to be composed of, and in the same proportion. By passing this through the various machines a test can be made of its yarn producing qualities, and the mixture of the larger stack can be varied so as to remedy any defects discovered in the smaller one. It is impossible to lay down any definite rule as to mixings, the production of which is a matter of experience, and can only be arrived successfully at in that way. Not only must the strength and cost of the yarn

be considered, but also its colour, and it is for this reason essential that a thorough knowledge of the structure and characteristics of various growths should be acquired in addition to one of commercial values.

(38) It will be easily seen, when the operations of the various machines employed in cotton spinning are considered, how essential it is that the fibres in a mixing should be approximately equal in length. Unless this condition is observed there is likely to be a good deal of loss from fly in the carding engine, and the slivers in the drawing frame would tend to have the long fibres in the centre and the short ones on the surface, owing to the difficulty experienced in drawing different lengths with the same setting of rollers. These remarks are, of course, only relatively true, as it is possible to mix different staples economically, but the process is a difficult one. For instance, in the scutching room, laps, each consisting of cotton of different staples, can be fed simultaneously on the same lattice, and so produce a lap of the mixed staples. It is found to give the best results when the laps are made on the opener and mixed on the intermediate scutcher in the proportion required. By these means a better mixing is obtained than if the laps are put on the finishing scutchor only. Individual experience is the guide to a thorough comprehension of this department of spinning, and beyond enunciating these general principles no aid can be given to the student which is likely to be of value. The actual condition of even the same class of cotton, in different seasons, varies so largely that a mixture which is valuable one season is unsuitable in the next.

CHAPTER IV.

THE OPENING MACHINE.

(39) Mixing being completed, the cotton is treated by machines specially designed to remove the impurities which are always mixed with it as received from the shipper. These impurities include sand, dirt, broken seed, and leaf. In addition to these there is a certain quantity of "nep" which is caused, as previously described, by the matting together of short, unripe, or immature fibres. To eliminate the whole of these substances, two sets of machines are required; the first being responsible for the removal of the heavier foreign bodies, such as sand and dirt, and the second for that of leaf, nep, and short fibres.

(40) Of the machines in the first division the opening machine, or more briefly the "opener," is the first. Its *raison d'être* is found in the matted condition of the cotton as taken from the bale, and the less open it is when taken from the stack, the greater the work of the machine. As the name indicates, the object of the latter is to disentangle the fibres, but it is also designed to remove many of the impurities held by the cotton. This twofold aim is the one with which all the series of cleaning machines are constructed.

(41) The method invariably pursued in opening is to beat the cotton by subjecting it to the blows of arms revolving with considerable velocity. It may aid in the understanding of the process, if a few words are said as to the primitive method of cleaning. Formerly the material was laid upon grids in small quantities, and was submitted to repeated light blows of rods or sticks delivered manually. In this way the mass was gradually beaten into a fleecy condition, and the dirt held by it dropped through the interstices of the grid. In some respects, this treatment has never been equalled, but it is, of necessity, very slow, and could not be commercially employed at the present day. At the same time, it affords a clear indication of the needs of the case, and is a guide to the proper treatment.

(42) In dealing with the fibre by revolving beaters of any kind, two things are essential to success. First, the blow given must be of such a character that the fibres are completely separated, while any rupture or breakage of them is avoided. Second, the surface against which the cotton is flung after being struck by the beater, must be arranged to permit of the free passage of all impurities, while, at the same time, so arresting the movement of the tufts or pieces of cotton as to shake out the extraneous substances.

(43) The direction in which the cotton enters the machine, the diameter, construction, and shape of the beater arm, and the speed of the beater, are three of the essential features of a machine of this kind. The successful removal of the impurities depends on the rate of the feed—that is, the amount of material passed into the machine in a given time—the shape of the projections on the casing surrounding the beater, and the distance of these from each other; in other words, their pitch. It is not a difficult matter to effectually

cleanse the cotton, so long as regard is not paid to the loss arising from damaged or broken fibres, or from the amount of fibre driven out with the dirt. It is, however, always to be remembered that it is desirable in any process to utilise every portion of the material which is capable of being worked up, and herein lies the chief difficulty of the subject. In brief, the essential consideration is a commercial one, and that machine is the best, and is used most skilfully, which effectually opens the matted cotton and shakes out the largest body of impurities with the least loss of fibre, either from its being driven out with the dirt or by breakage or rupture. Economy and efficiency are the watchwords of a good spinner, and nowhere is this combination more desirable than in the early stages of the manufacture.

(44) There are three principal forms of machine used for the purpose of opening—the Oldham Willow, the Porcupine, and the Crighton Opener. The former is now employed rarely for cotton, but extensively for the manufacture of yarn from waste. The other two are often employed, but the Crighton type of machine is perhaps more widely used than any other. There is another type of machine, which is also in extensive employment, to which reference should be made, viz., a modified opener, on the Willow model, of which a description will be given.

(45) The Willow is constructed with a revolving cylinder, about forty inches wide and the same diameter, fixed on a shaft borne by suitable pedestals. It is provided with several rows of blunt teeth on its periphery. Above the cylinder a semi-circular casing is fixed, which is provided with similar projections to those of the cylinder. Below the latter a grating, grid, or "undercasing," formed of a number of parallel bars, is placed. The cotton is flung against these bars, and the loosened dirt falls through the spaces between them, being drawn away by an exhaust fan and delivered outside the room. It is the usual practice to feed the machine by an endless lattice, or apron, of a similar construction to that previously described. When the cotton enters the machine it is struck by the teeth on the cylinder and thrown forcibly against the projections on the casing. The blow thus given, combined with the periodical arrest of its motion, causes the cotton to be thoroughly opened and shaken, the dirt falling downwards and being drawn away by the air current. As has been said, the Willow is falling into disfavour. The cotton is subjected to too severe punishment, and is therefore damaged. In addition to this, it is sometimes carried round several times, and is formed into a sort of ropé, which renders its subsequent treatment more difficult. Moreover, the waste is greater than is desirable, and, generally speaking, the use of this machine for cotton is of doubtful utility.

(46) In Fig. 9 a longitudinal section of an opener, which in some respects is a modified type of willow, is illustrated. This machine is made by Messrs. Taylor, Lang and Co., Limited. It consists of a feed lattice Q, which travels in the direction of the arrow, and delivers the cotton to the pair of feed rollers shown. These are duplicated when no regulating apparatus is used, and are three inches in diameter. The cotton is delivered at any desired speed by the rollers, and as it projects from them is struck by the spikes or teeth on the cylinder O, which revolves in the direction shown by the arrow. Surrounding the cylinder is a case P, the inner surface of which has a number of projecting nogs formed on it, against which the cotton is flung with considerable force. This shakes out the dirt to a great extent, and opens the material. After passing the casing P

the cotton is taken over a circular grid surrounding one side of the cylinder, and contained in the body of the machine. This grid is formed of a number of steel bars, between each pair of which an opening is left. Thus as the disentangled cotton passes over it the heavy dirt falls out through the openings into a space left for the purpose. After passing the grid the material leaves the cylinder by the passage shown, immediately on entering which it travels over the top of fixed grids R, through which the sand and similar material can fall. After this the cotton is either delivered into the room or is carried forward to a pair of "cages" S, through which a current

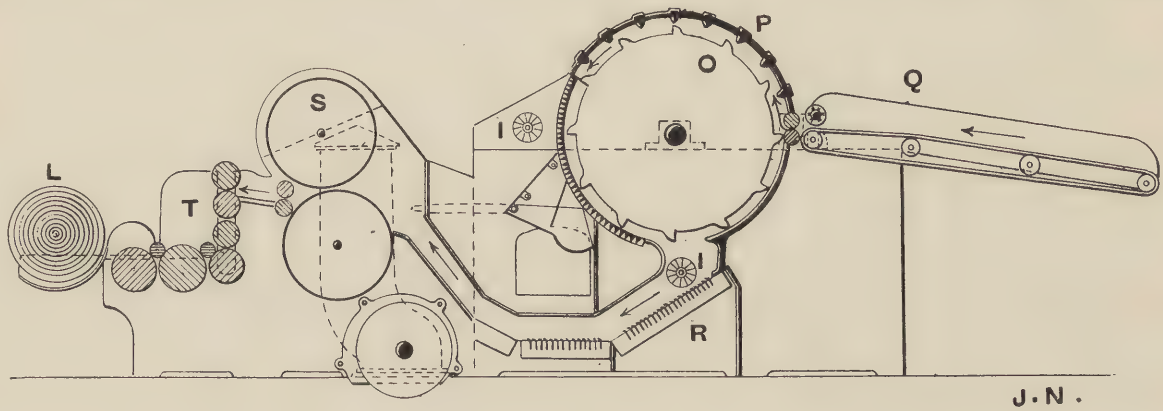


Fig. 9.

of air is drawn. This part of the machine will be described in the next chapter, and it is only necessary to say that the fleece of cotton is formed into a sheet and rolled up as shown at L, into a "lap." If the cotton is delivered loose it is thrown on to a second lattice, by which the delivery is made. In order to secure a regulation of the air current the louvre openings I are provided. The area of the cleansing surface in this machine is great, and 50,000lbs. of cotton can be cleaned in a week of 60 hours unless a "lap" is formed, when the quantitity is reduced to 28,000lbs.

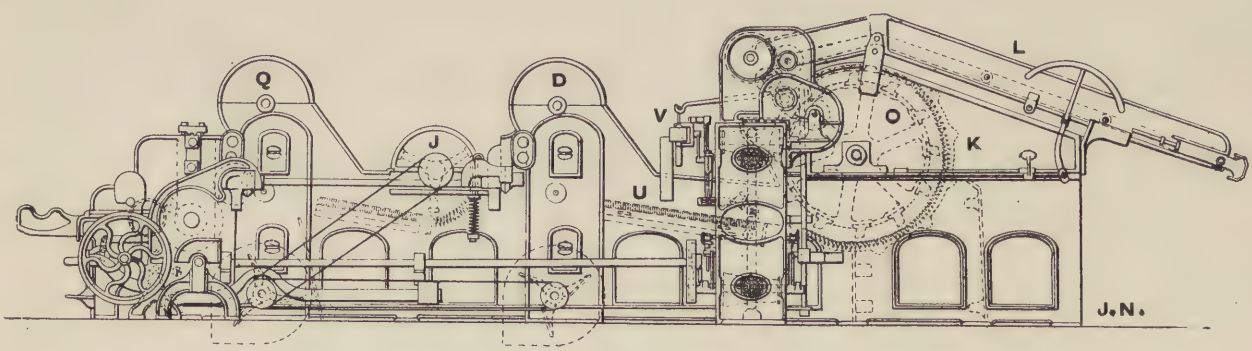


Fig. 10.

(47) In Fig. 10 is illustrated, also in longitudinal elevation, a machine made by Messrs. Dobson and Barlow. The cotton is fed by a lattice L, as in the preceding example, the course of which is clearly shown. In this case the machine is fitted with pedal levers V, these being employed to regulate the feed. This motion and its method

of action will be described at length in the next chapter. It suffices to say that the cotton on issuing from the feed roller is struck by teeth or projections on the surface of the cylinder O which revolves from left to right. Surrounding the latter is a semi-circular grid K with conical teeth, which encircles the cylinder for more than half its circumference, through which the dirt is thrown, the cotton being cleaned by these means. It will be noticed that in this machine the area of the circular grid K is large, and that the material at once passes upon it after it is struck by the cylinder. As soon as the cotton leaves the surface of K it is carried forward over the grid

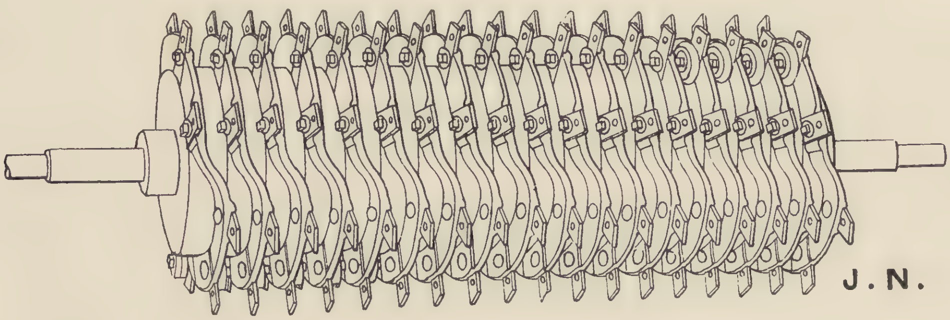


Fig. 11.

U, placed in a position well calculated to allow of the easy movement of the material, and by means of which the removal of the dirt and sand is more easily effected. The grid U is also made of considerable area, so as to afford a large cleaning surface, which is a desideratum in this class of machine. After leaving U the cotton is collected on the cages D, and subsequently passed through the scutching machine, which in this case is combined with the opener. As this machine is used as a separate one, it will be better to leave its description until it is dealt with by itself. It is only necessary to say that it will be shown by numerous examples that the whole of the

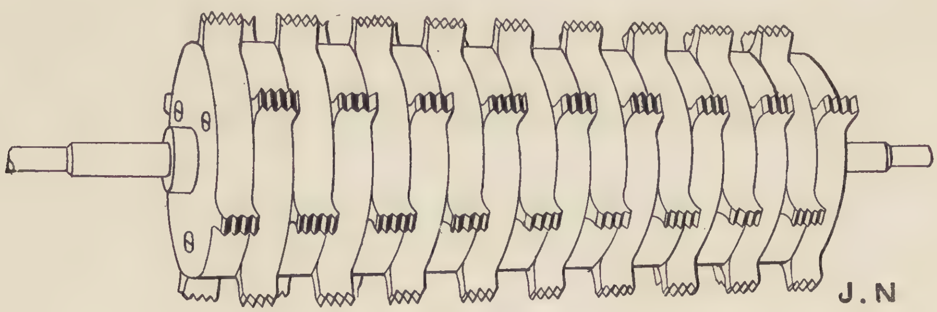


Fig. 12.

cleaning machines are often combined in various ways, which are arranged to suit the special circumstances of any case. These are so different that the combinations are widely diverse.

(48) The Porcupine opener is so named from the employment of a cylinder or beater consisting of a number of teeth spikes or blades. Two forms of the beater, as made by Messrs. Lord Brothers, are shown respectively in Figs. 11 and 12. The form shown in Fig. 11 is intended for use in cleaning long-stapled cotton, and consists of a number of discs secured to a central shaft. To these steel blades are bolted, which are so shaped that they

can be reversed when worn. The beater illustrated in Fig. 12 is formed of a number of cast-iron discs, each of which is hollowed on one side, and has a projecting flange or boss on the other. These are turned to fit one another, and are bolted together by long screws. They are further bound by a nut fitting on a screwed part at one end of the shaft, by which they are pressed against a collar at the other end. The teeth are V shaped and are chilled, being readily sharpened after wear. In the event of the teeth of one of the discs being broken, it is only necessary to remove it by breaking it up. An additional disc can then be put on the end of the shaft, and the whole screwed up again as at first. In this way the whole of the advantages of a solid roller are secured, with much greater facilities for repair.

(49) However the cylinder is constructed it is sustained by bearings secured to the framing of the machine. Beneath it a grating or grid is fixed, similar in construction to those previously described. The bars are in all cases shaped so as to present a sharp angle to the cotton as it is thrown forward by the cylinder. A dirt chamber is, as usual, formed below the grid. The cotton is fed by a lattice and feed rollers. The latter are

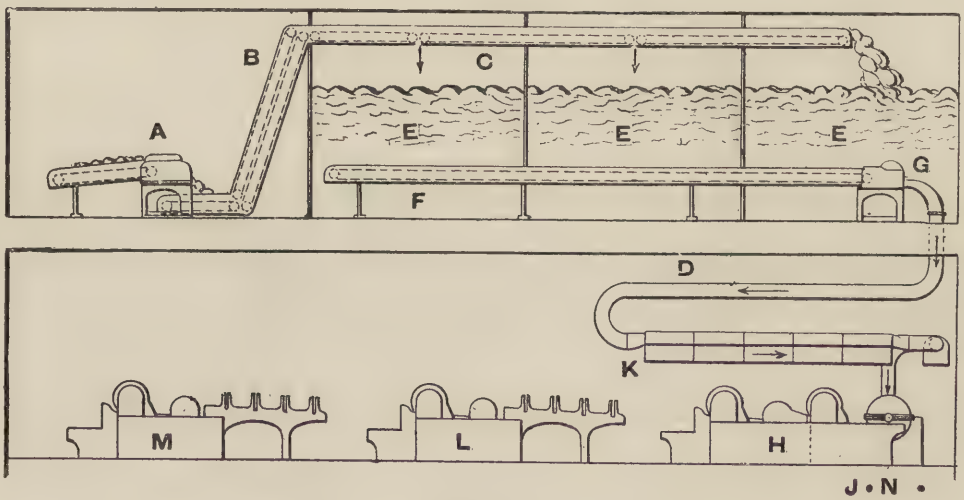


Fig. 13.

formed in the ordinary way, with a number of circumferential V grooves, crossed by a series of similar longitudinal grooves, so as to form a large number of teeth, which securely hold the material as it is fed. As the cylinder revolves 1,000 times per minute, the teeth strike the cotton and disentangle the fibres, throwing them with considerable force against the grid.

(50) Although the Porcupine opener can be used separately and the cotton discharged into the room, it is more usually employed in connection with some other type of opener, or with a scutching machine. Formerly it was a common practice to use this machine separately, in which case it was fitted with two cylinders one behind the other. Now it is mostly employed as a feeder to another machine, and the combination gives very effective cleaning.

(51) Such an arrangement is shown in Fig. 13, which is a special one of Messrs. Platt Bros. and Co. The lattice feed F is placed alongside the mixing bins, and is provided with a large collecting roller,

behind which are a series of pedals, described in the next chapter, and two pairs of breaker cylinders. By these the cotton is fed regularly and broken up into small pieces, or partially opened before being passed forward to the opener cylinder. The Porcupine feed rollers G deliver the cotton, in the case illustrated, into the air tubes D, and thence over a patent dust trunk K, where much of the dirt is deposited, and which is afterwards described.

(52) The opener, as made by Messrs. Platt Brothers and Co., Limited, is shown in perspective in Fig. 14. The cotton enters the opener chamber by the tube, as described, and is at once acted on by the cylinder, which revolves horizontally. The cylinder is surrounded by grids, against which the cotton is thrown, and through which the dirt is ejected. The forward movement of the cotton is induced by the exhaustion of the air, produced by means of a pair of fans, placed one at each side of the machine and adjoining the exit orifice

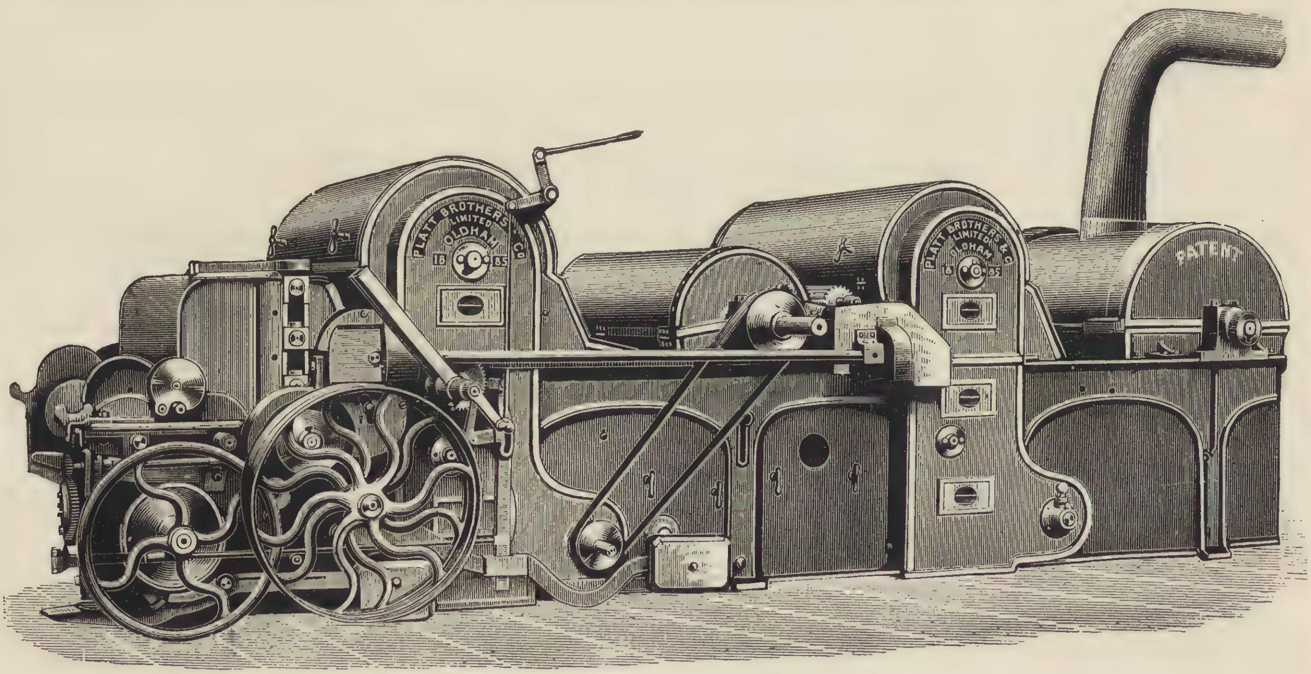


FIG. 14.

from the cylinder chamber. Power of lateral adjustment is given to these fans, so that they may be set in towards the centre of the machine to a greater or less extent. In this way the stream of cotton, as it issues from the cylinder, is directed on to the cages as required, and a very even lap or sheet is thus obtained. It is obvious that the guiding power of the air current is the right thing to rely upon, and, by the arrangement described, ample regulation of it is obtained. A lap which is even in thickness is absolutely essential to good work, and the arrangement of fans in the way described ensures this being obtained. The author recently saw the first lap made on a machine of this type in a large Oldham spinning mill, and the regularity of the thickness and evenness of the selvedge was very noticeable. The machine as shown in Fig. 14 is a combined one.

(53) The Crighton Opener is a machine the distinctive feature of which is the employment of a vertical conical beater. A sectional elevation of the machine as made by Messrs. Crighton and Sons is shown in Fig. 15. The beater consists of a number of cast-iron discs D securely keyed upon a vertical shaft, which is sustained at its lower end by a bearing E in the frame F, and at its upper end by the bearing A. On the discs are fastened steel blades, and it will be noticed that their diameter increases from 18in. to 33in. Surrounding the beater is a casing B, in which are a number of longitudinal slots, the inner surface of the grids being in most cases made of the shape shown in section in Fig. 16. A recent improvement by Messrs. Crighton and Sons is shown in Figs. 17, 18, and 19.

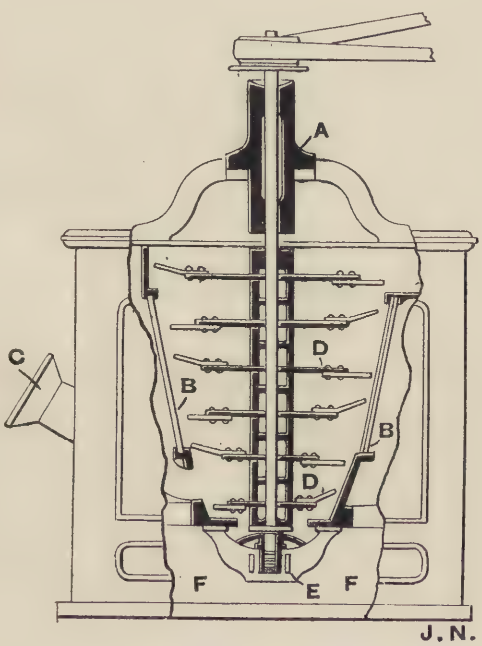


Fig. 15.

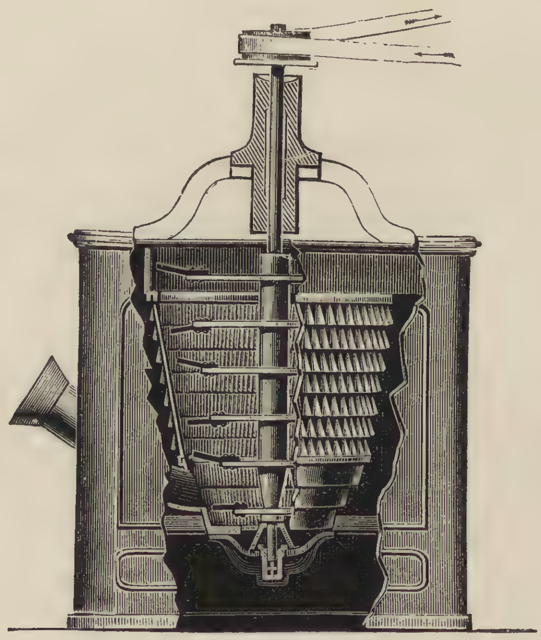


Fig. 17.

(54) The cotton is fed by the tube placed at C, and a fan is fixed just below the entrance of the tube into the beater chamber. The direction in which the cotton enters and the positions of the fans are important points of construction. The feed tube is not fixed in a straight line, but is slightly curved so as to direct the cotton upward as it enters the beater chamber. As it enters it comes in contact with the serrated surface of a truncated conical dish, within which the lowest arm D of the beater revolves. Immediately below this dish a fan disc of the Schiele type is fixed in machines in which a combination of feed table, air trunks, and opener is made. The object of this fan is to exhaust the air in the tubes up to that point, and draw the cotton forward until it reaches the cylinder. There is a decided advantage in this arrangement over one in which the fan is placed beyond the exit orifice at the top of the opener chamber. In the latter case the air is required to draw the cotton through the dust trunks into the opener, upwards past the cylinder, and so on to the cages. In the machine as made by Messrs.

Crighton, the fan at the bottom of the dish is sufficient to bring the cotton to that point, and all that is subsequently required of the fans placed beyond the cylinder is to lift the cotton upwards during its progress through the beater chamber. On this account a slower moving current of air can be employed, and the fans connected with the cages can be revolved at a less velocity. The full advantages of this arrangement will be afterwards pointed out, but as the cotton is raised slowly while being beaten, it is thoroughly opened and cleaned.

(55) When the cotton enters the beater chamber it is at once struck by the blades of the beater, which revolve at a speed of about 1,000 turns per minute. The peripheral velocity of the blades is thus at the bottom 4,712 feet per minute, and at the top 8,639 feet. The blow thus given disentangles the cotton and flings it against the inner surface of the grid, thus momentarily arresting its motion. As the beater revolves, the cotton

Fig. 16.

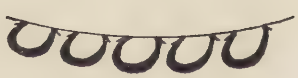


Fig. 19.

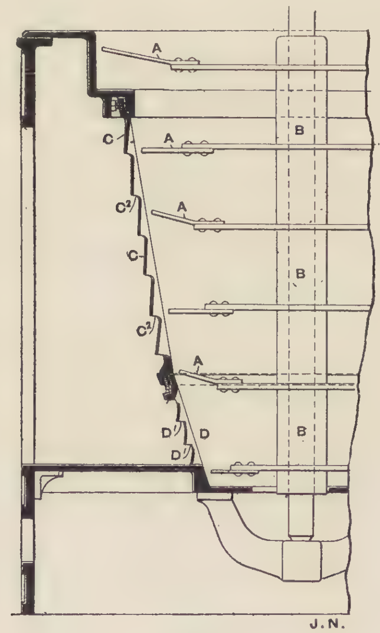


Fig. 18.

continues to find its way upwards, and in its course is repeatedly struck by the blades, which, as has been seen, have a continually increasing peripheral velocity as they near the top. In this way, as the cotton nears the exit orifice, which is placed at the upper part of the machine frame, on the opposite side to the tube C, it is thoroughly beaten into a fleecy condition, with its fibres well disentangled.

(56) The shape of the grids surrounding the cylinder is an important matter. In the form illustrated in Fig. 16, the projections on the grid are triangular in shape, and have slots between each pair through which the dirt can freely pass. It will be easily seen that the shape of these grids is one which will only exercise a little clinging effect upon the cotton, which, as it is impelled by the stroke of the beating blade, will very readily roll pass the projections. As the rapid rotation of the cylinder tends to slightly compress the air, the latter finds an outlet if possible. This is the object of the slots in the grid casing, and they

fulfil it very well. But there is always a liability that along with the air and dirt—which also passes the grids—a little fibre may escape. It is desirable to avoid "fat droppings" as they are called, and the grid shown in Figs. 17 to 19 has been designed for this purpose. Each of the pockets C Fig. 18 shown becomes a resting place for the opened fibre, and as its lower end C^2 is open, the dirt can fall freely. In order that the air can easily get away, between each pair of pockets a small slot is formed, and in this way there is no downward impulse given to the cotton while held in the pocket. Thus each blow given to the material opens it, drives it into the pockets where it dwells for a short time, and from which after the passage of the beater blade A, it is drawn by the suction of the air. By this system there are given short periods of rest, which very materially facilitate the fall of the dirt.

(57) Instead of feeding the opener manually as shown in Fig. 15, a lattice feed can be adopted. Among the many important points in connection with the Crighton, or, as it is sometimes called, the "exhaust" opener, none is more so than the construction and lubrication of the footstep. This is arranged so that the foot of the beater shaft revolves in a constant bath, either of oil or water, and great care is taken to cover it so as to prevent the entrance of sediment or dust.

(58) In Fig. 20, a longitudinal section of the machine as made by Messrs. Lord Bros., is given, and is accompanied by a plan of the same machine as combined with a porcupine feed. Referring first to the plan, the lattice feed A delivers the cotton to the porcupine roller C, by which it is passed in a partially opened condition to the air trunks D. By these it is conducted to the opening chamber F, being admitted to it by flap valves G. The cotton enters the chamber F by the tube H, terminating in the dish I. The exit orifice is placed at the top of the chamber F, the course of the cotton being shown by the arrows. The cylinder is similar to the Crighton, but the blades E are fixed in malleable iron arms L fastened to the shaft, and can, after wear, be reversed. Below the foot of the shaft, and within the bearing O, is a loose washer P, which can rotate with the pressure of the shaft, this arrangement considerably lessening the wear. At each side of the exit of the delivery tube, fans N are fixed, which, like those in the Platt machine, can be adjusted sideways for the same object. The cotton then passes over grids R on to the cages T, from whence it passes through the scutching beater W to another pair of cages S, as indicated by the arrows, and is finally formed into a lap as shown. The special construction of the beaters enables the cotton to pass freely upwards, and prevents any stringing occurring. The speed of the beater in this machine is 520 revolutions per minute for American cotton, and 720 for Indian. The slower velocities used necessarily imply the use of less power.

(59) There are one or two points to be noticed in concluding the consideration of the Crighton type of machine. The distance from the face of the grids to the ends of the beater blades should be carefully arranged to suit the class of cotton treated, as, if it is too great, the opening is not properly effected, and, if too little, the cotton is liable to be damaged. The rate at which the feed is conducted should always be carefully watched, because, if the material is passed in too quickly, its bulk becomes so great in the lower part that the dirt cannot fall freely, but is received by the entering cotton. Cleaning is not, therefore, so effectually carried out. In addition to this, it is desirable that the cotton should be allowed to assume a perfectly open condition, which it would do with difficulty

if the space were overfilled. Cotton has been passed through, for a short time, at the rate of 110,000lbs. per week of 60 hours, but for the reasons stated, 30,000lbs. is ample.

(60) It might be thought that the pitch of the projections on the inner surface of the grid should be as small as possible, but this is a mistake. It is essential that the cotton should strike not merely the top or apex, but one face or side of the projection, if the full cleaning effect is to be obtained. It is obvious that if the pitch is too fine no such face blow would be given, and very inefficient purification would occur. The considerations thus stated are founded on actual experience in working the machines, and should be borne in mind in constructing or controlling an opener of this type.

(61) It is considered by some makers to be advisable when using this style of machine to employ one with two beaters revolving in separate chambers, connected to each other by an air pipe. This is more especially the case when Indian or short stapled cotton is used. When the double machine is used, the conducting tube between the two leaves the first chamber at the top, and enters the second at the bottom. The driving of the opening machine is usually obtained from a counter shaft, by which means the speed of the driving pulley becomes a moderate one.

(62) A machine, of which large numbers have been made by Messrs. Lord Brothers and Howard and Bullough, has a conical beater placed in a horizontal position, and the opener proper is usually combined with a scutching and lap machine. As this type of machine is very similar in its general principles to that previously described, and is not now so largely made as formerly, it is not necessary to give a detailed description of its mechanism.

(63) It has been repeatedly stated that the various machines are united by means of tubes, so that the cotton can readily be taken from one machine to another. It does not matter whether the machines are in the same room or not, or what distances separate the rooms in which they are placed. This has been shown in Figs. 6, 7, and 8, referred to in the preceding chapter, and the further arrangement is illustrated in Fig. 13. In this case the cotton, after being delivered into the dust trunk, or tube D, on its way to the opening cylinder, may be carried two or three hundred yards, if desired, before it reaches the latter. There is, of course, a limit to the distance it may be conveyed, but it is a very wide one. There are many conveniences arising from this procedure. It is becoming a very common practice to build the mixing and scutching rooms away from the main body of the mill in order to minimise the risk of fire. But even where this practice does not obtain, the employment of air tubes is a good one, as it enables the material to be transferred from one point to another without handling. In this way the cost of labour is much reduced, and in addition the cotton is less liable to damage.

(64) At one portion K of the conducting tube D an arrangement is fitted by which a partial cleansing of the cotton occurs before it reaches the opener. Below the level of the tube a chamber nearly square in section is formed, as shown in section at the left-hand corner in Fig. 20, forming the tube into a D shape. This chamber is made of a length which is determined by the character of the material used and considerations of its position, etc. At intervals of a few inches plates are arranged so as to divide the chamber into a number of compartments, as shown by the sectional view. Over the top of these plates the material rolls

in its forward movement, and a large quantity of dust, sand, and heavy impurities are deposited in the trunk. Doors are fitted to the underside of the chamber, by which the droppings can be removed at intervals as desired. The use of these grids has been attended with unmistakeable benefit, and leads to a much more effective cleaning of the cotton.

(65) By the method just described it is necessary to cleanse the trunks manually at intervals, and if any neglect occurs there is some danger of the dirt being carried forward. To obviate this, Messrs. Platt Bros. and Co. Limited have patented and applied the arrangement shown in Fig. 21. In this case the dust chamber L is sus-

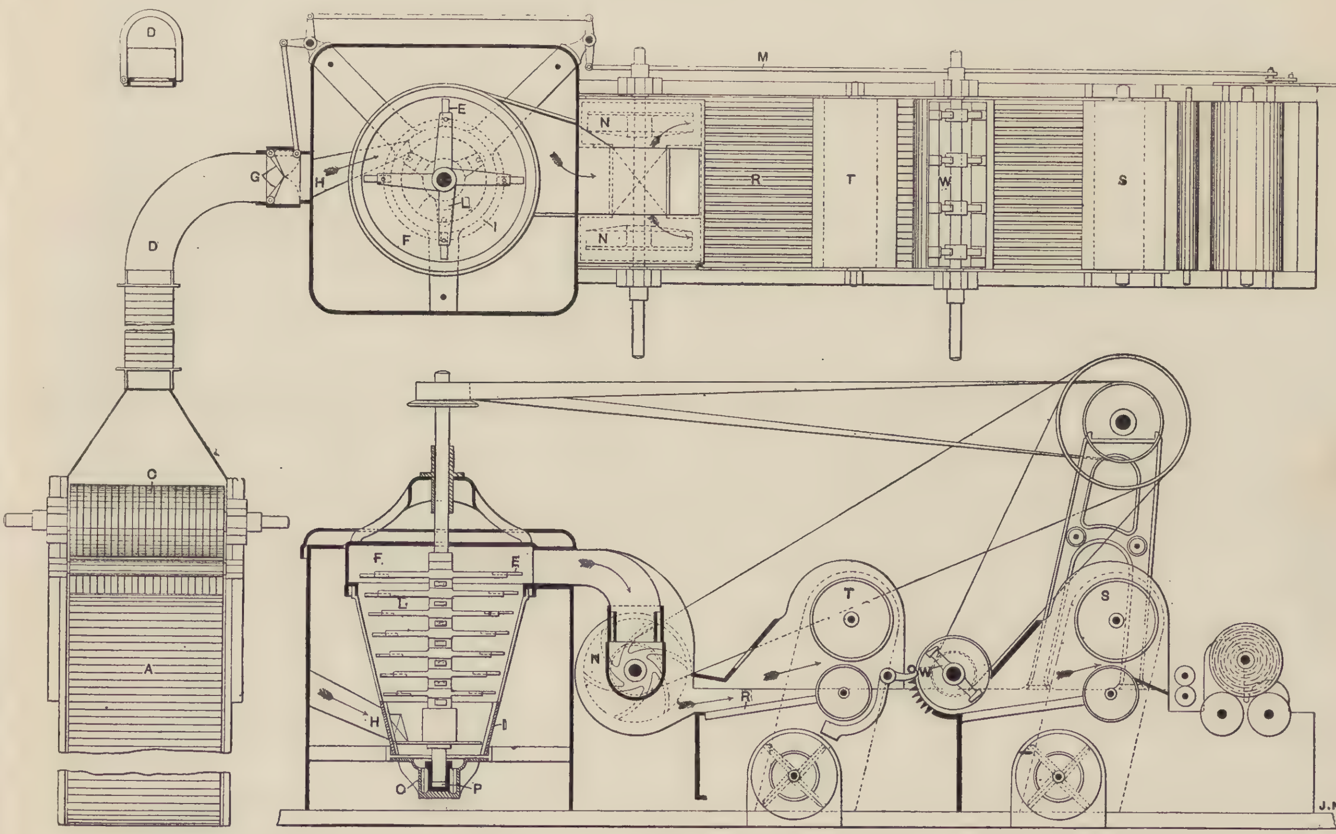


Fig. 20.

tained in a manner arranged to suit the circumstances of the case. Instead of being fitted with the vertical plates described, an endless band is carried over two drums, one at each end of the chamber. This band K is driven from the pulley shown by means of worm gear, and receives a traverse at its top side in the reverse direction to the air current. On the band are fitted a number of blades or teeth, between which the dust or dirt can fall. The traverse of the lattice carries the dirt forward, and when the teeth are turned downward it falls into the spout or receptacle N, and on to the top of an iron flap P, usually kept in a horizontal position by the balanced lever fitted

on the spindle on which the flap oscillates. The collection of a sufficient quantity of dirt destroys the equilibrium and causes the flap to tip, allowing the dirt to fall into a sack suspended below the orifice to receive it. In the event of any dirt falling on to the bottom of the chamber, two or three special blades are arranged to scrape

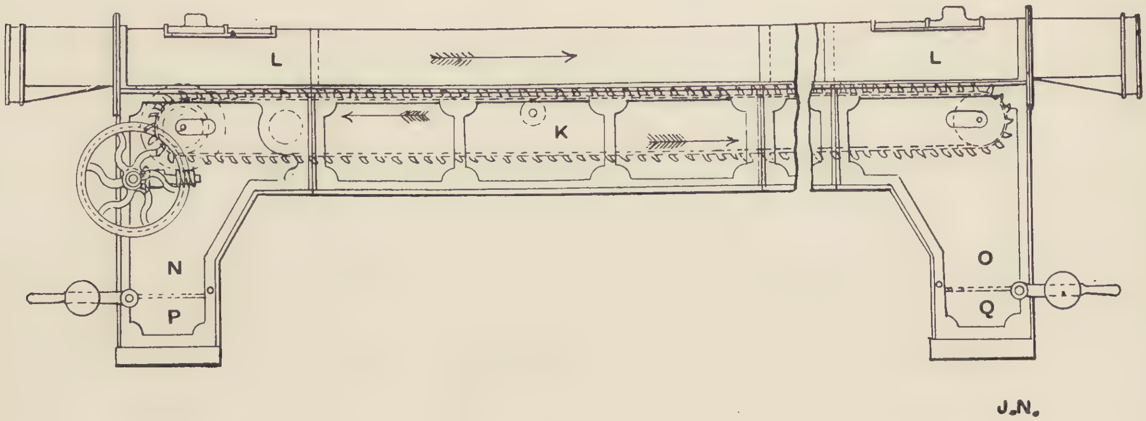


FIG. 21.

along it and draw the dirt to the other down spout O, where a similar action occurs. This arrangement has two advantages. It constantly presents to the advance of the cotton new and clean receptacles for the dirt, and it automatically removes the latter from the path of the material. These are decided improvements, and the arrangement is a considerable advance on its predecessor.

CHAPTER V.

THE SCUTCHING MACHINE.

(66) After the cotton has been opened by any of the machines just described it is passed into a machine commonly known as a "scutcher." In this it is subjected to a further beating action, which in this case, however, has the object of cleansing rather than opening it. Machines of this class may be either single or double, that is, the cotton may in passing through the machine be subjected to the action of one or two beaters. Occasionally, but very rarely now, three beaters are used. It is becoming a more general practice to use an opener and single beater combined as a first stage and a single beater machine as a second stage, but there is no fixed rule in this respect, the actual facts of each case determining the procedure. At one time the opened cotton was ejected in a loose condition from the opener, and was placed upon the scutching machine feed-table by hand, often being weighed. As an English practice this is becoming obsolete, the system of pneumatic suction being employed to convey the cotton from one machine to another. Openers have very often attached to them a lap machine, which forms the cotton into a roll or "lap." As the "lap" attachment is one which is common to most cleaning machines a description may be given of it at this point.

(67) This attachment consists of two fluted rollers (L L Fig. 22), which are suitably revolved, and on which the roll of cotton M is formed, being lapped round a rod or tube by the frictional contact of its surface with the rollers L. Before it reaches this point the cotton is formed into a sheet on the dust cages, as described in the preceding chapter. The iron rod or tube is made long enough to act as an axis for the lap to revolve on, and to enable it to be carried about from place to place for further treatment by succeeding machines. As the sheet or fleece leaves the dust cages J it is passed between a pair of smoothly turned rollers, the upper one of which is weighted so as to calender or compress the lap. This is a matter of some importance, as it renders the surface of the lap smoother and prevents the various layers adhering to each other when unrolled. An arrangement is fitted by which the attainment of a defined diameter of lap releases the setting on handle, causing the latter to move and transfer the strap on to the loose pulley stopping the machine. The importance of forming laps is now well recognised, and will be dealt with at greater length at the end of this chapter.

(68) Fig. 22 represents a side elevation of a single scutching machine, as made by Messrs. Lord Brothers, that is, one which beats the cotton once. It contains a revolving beater A, fixed upon a central shaft and driven at a high velocity from a counter shaft. The beater consists of arms, forged solid, with a central boss, and having feet at their outer ends. The arms are keyed firmly on the shaft, and may be either round or elliptical in shape. There are either two or three arms on each boss, and a number of them are secured to the shaft along its length

within the beater case. According to its construction the beater is known as a two or three "winged" beater. However made, it is carefully shaped and machined, so as to be in perfect balance, and this is a most important point in the construction of the machine. Too much stress cannot be laid on the necessity for extreme care in this matter. Not only should the beater arms be balanced prior to fixing, but after having been keyed on the shaft the same operation should be carried out. In order to balance the beaters thoroughly it is better to revolve them rapidly, while sustained in bearings having freedom of sliding movement in a frame. The velocity at which they are tested should be considerably in excess of that at which they work, and no pains ought to be spared to get the beater in absolutely true balance when working. Otherwise the vibration set up would be considerable, and the character of the blow given would be intermittent instead of regular. Before the final balance is given the blades should be attached to the arms. The blades are made

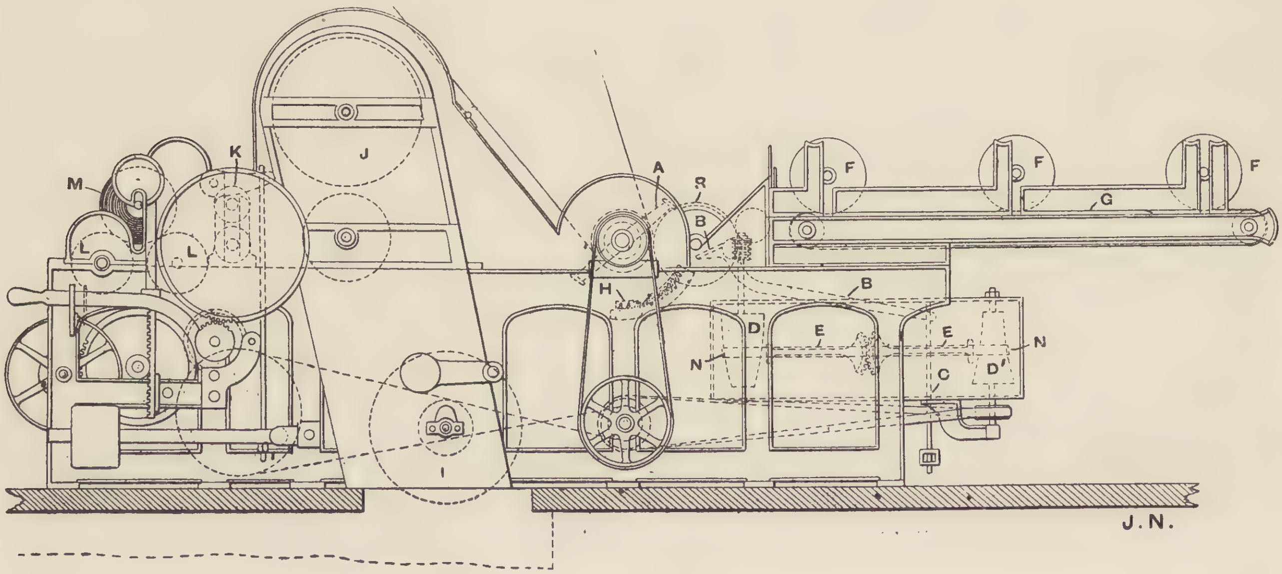


FIG. 22.

of steel—or of a combination of steel and iron fused together—of an irregular section, angularly formed at one side, so as to present a moderately sharp face to the cotton as it strikes it. The blade requires to be made with a slight clearance, so as not to rub the cotton after striking it.

(69) The question as to which is the better form of beater to use—a two or three-winged—is one which is difficult to answer. Most makers to-day are using the former, while others—as for instance, Messrs. Platt, Brothers and Co.—while employing a two-winged beater for the "breaker," use a three-winged for the "finisher" scutching machine. From the constructor's point of view the two-winged beater has undoubted advantages, as it is at once more easily made, and balanced with much less difficulty. The diameter of a two-winged beater is usually 14 inches across the blades, and of a three-winged 16 to 18 inches. The velocity of the former is greater than that of the latter, being in one case 1,200 to 1,500 revolutions per minute, and

in the other 900 to 1,000. Thus the peripheral velocity of the two-winged beater is from 4,314 to 5,497 feet per minute, and that of a three-winged, 4,100 to 4,700 feet per minute. Although a three-winged beater, running at 1,000 revolutions, will strike the cotton 3,000 times per minute, the two-winged form, running at the higher velocity of 1,500 revolutions, will give the same number of blows. There is, however, the character of the blow to be considered. The smaller diameter in the case of the two-winged enables the higher velocity to be reached, and the blow given is sharp and quick. In addition to this, the smaller circle described by this form of beater causes the blade, after having struck the cotton, to leave it rapidly; whereas the larger diameter of the three-winged one leads to the blade being longer in contact with the cotton than it otherwise would be. This, coupled to the comparative slowness of its peripheral velocity, gives a dragging blow, which is not a good thing for the cotton, as it is apt to crush or bruise the fibres. The longer the staple the slower the velocity of the beater should be, and this has an important bearing on the subject. For instance, with good cotton, the velocity of a two-winged beater is sometimes reduced to as low as 1,000 revolutions, while with Indian cotton the higher velocity is preferable. These considerations tend to show that the two-winged beater is the most suitable.

(70) There is another point which, however, deserves a word or two. The regularity of the pulsations of a scutcher beater is a matter requiring consideration. It is a subject not always thought of, but it has a great influence upon the resultant lap. The cotton—as will be hereafter shown—is struck from a roller or pedal, and is thrust into the range of action of the beater blades at a defined and regular rate. As it is desirable to beat it into small tufts before flinging it on to the grids, and as the cotton is liable to damage if the pieces struck off are too large, it follows that the oftener the blades strike the better. That is, of course, assuming they do not strike so often as to powder or crush the fibre. Now, there is no reason in this consideration, for the employment of a three-bladed beater, which does not strike the cotton more frequently than is the case with one with two blades.

(71) It is usual to form laps at the termination of each scutching process. These are first made, in most cases, on the opener, or failing that, on the breaker scutcher. The laps thus made are fed to a second machine called the finisher scutcher, where a new lap is made, which is fed to the carding engine. It is therefore desirable to obtain the utmost regularity in the last lap named, and for this reason the pulsations of the beater become important. On this account Messrs. Platt Bros. and Company use a three-winged beater in their finisher scutcher, believing that the result is more satisfactory.

(72) Surrounding the beater at its upper portion is a case, made quite air-tight. Beneath the beater a grid H is placed, the bars of which are set to present a sharp edge to the cotton. The number of these varies according to the class of cotton used. Careful regard should be given to this factor. In fixing the bars they should be placed as shown in Fig. 24. The front bars C should have their cleaning edges set a little in advance of a perpendicular line drawn across an imaginary line horizontal to the axis. The angularity thus given should decrease as the bars are further from the feed roller. The reason of this is obvious. As the cotton is struck from the feed rollers it is desirable that it should receive a sharp check at once, in order to shake out the freshly-freed

impurities. This requirement becomes less urgent as the cotton passes onward and the arrestment of it traverse is less necessary.

(73) The circle described by the top of the bars should not be concentric with that of the beater blades, but ought to be as shown in Fig. 24, further from the centre of the beater shaft at the back than it is at the front of the grid. The reason for this is that the bulk of the cotton after being scutched becomes greater, owing to its more open condition, and it naturally requires more room, to avoid any choking or entanglement. Further, if the grid is comparatively long the distance between the bars—in other words, their pitch—must be increased. Below the bars is a chamber into which the dirt can fall freely, and which is closed by doors from without. The pitch of the bars should be large enough to permit of the easy passage of the dirt.

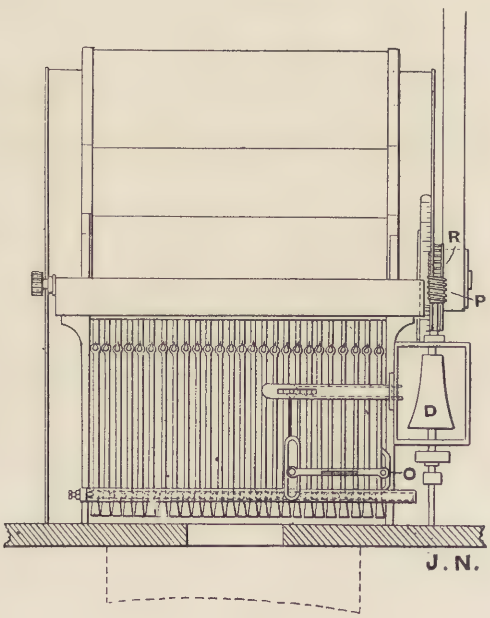


Fig. 23.

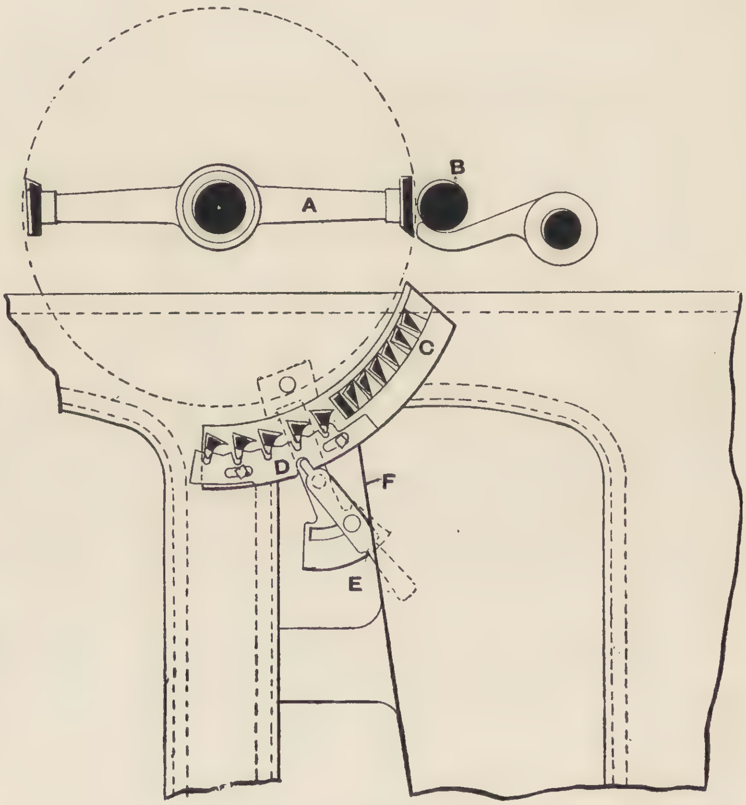


Fig. 24.

(74) Messrs. Howard and Bullough use, in addition to the fixed bars shown, the additional bars D, which are pivoted at their lower end, as shown, in a movable plate. This plate is attached to a lever E, which can be operated from the outside. The purpose of these bars is to admit of the admission of more or less air as desired. The space below the fixed bars and that below the air bars are separated by a thin division plate F. It is claimed for this arrangement that the fall of the dirt through the bars C is considerably facilitated.

(75) After passing the dirt grids, the cotton falls on to a second grid, or plate, as preferred, and then between a short "dead" plate and "beater sheet" to the cage J on to which it is drawn. The cage J consists of a skeleton cylinder revolving on a shaft, and having its periphery formed of finely-perforated sheet metal. Each end of the cage terminates in an air passage or trunk extending upward as shown. At the foot of the trunk the fan I is placed, which exhausts the air through the cages, and sucks the cotton on to them so as to form a continuous sheet or fleece. From the cages the fleece is taken to the lap attachment, which has been previously described.

(76) Messrs. Crighton and Sons, a perspective view of whose machine is given in Fig. 25, make their cages in a somewhat different manner to that just described. The ends of the cages are fitted into the framing, which is recessed at each side to receive them. Their peripheries are formed of woven wire webbing, instead of the perforated zinc sheets mostly used. At the end of the cage the webbing is protected

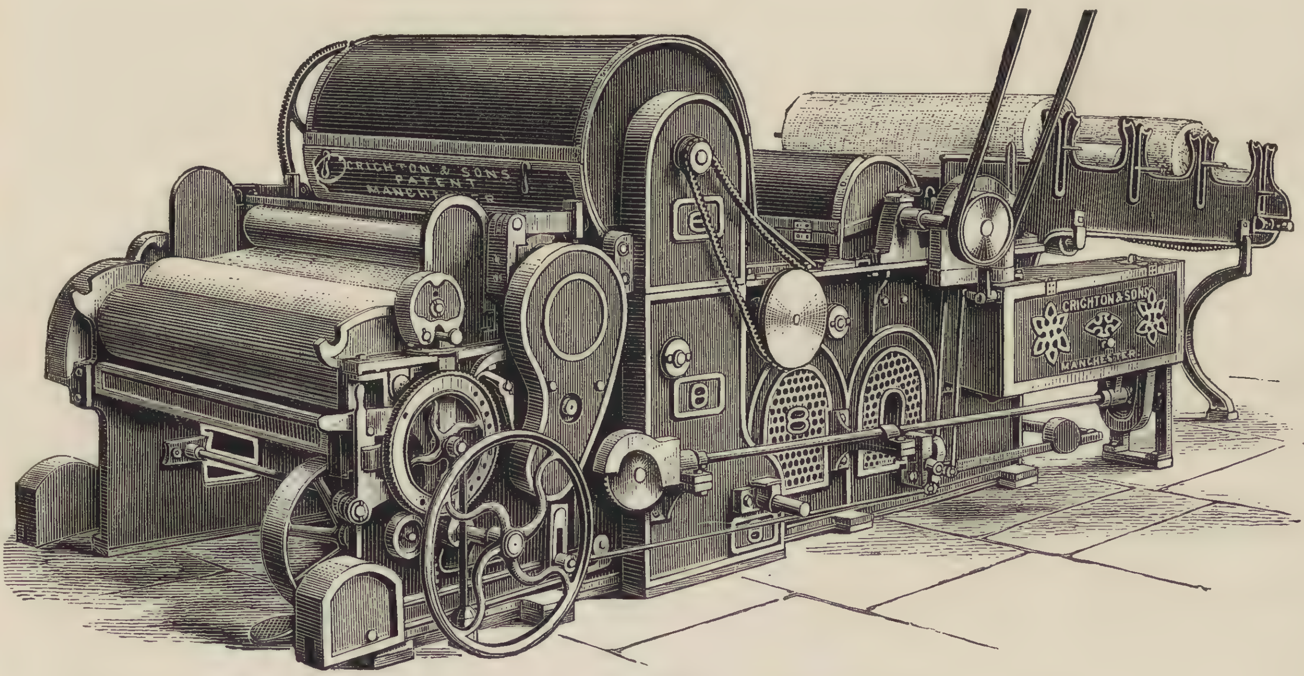


Fig. 25.

by a brass ring, which keeps it firmly in position. The effect of this arrangement is two-fold. A greater space is left for the passage of the air than is possible with a perforated metal covering, and as a result, the intensity of the current is reduced. In addition to this, the fleece of cotton is laid on the whole of the face of the cages, because the manner in which they are fitted into the framing practically causes the latter to act as a guide, beyond which the cotton cannot spread. In this way the edge, or "selvedge," of the lap is rendered very even, a subject the importance of which is further dealt with in paragraph 99.

(77) Another point of special construction, adopted by the same firm, is the position of the "dead plate." This is the name given to a plate below which the scutched cotton travels, extending across the machine

immediately behind the beater. As the cotton leaves the range of the beater, it falls upon a plate or sheet called the "beater sheet," immediately below the "dead plate." Now, for reasons to be given, the position of this plate is important, and in the machine as made by Messrs. Crighton, its distance from the beater sheet is $2\frac{1}{2}$ inches. Immediately beyond this point the same firm use an appliance known as a "leaf extractor," of which an illustration is given in Fig. 26. It consists of an endless brattice or canvas band D, as wide as the space between the frames, and having fastened to it transverse bars of wood B. These are shaped as shown, with an edge meeting the cotton as it moves forward, thus scraping off the leaf, and the space contained between each pair of these practically forms an air-tight box for the reception of the leaf. The brattice moves in the direction of the arrow, and thus

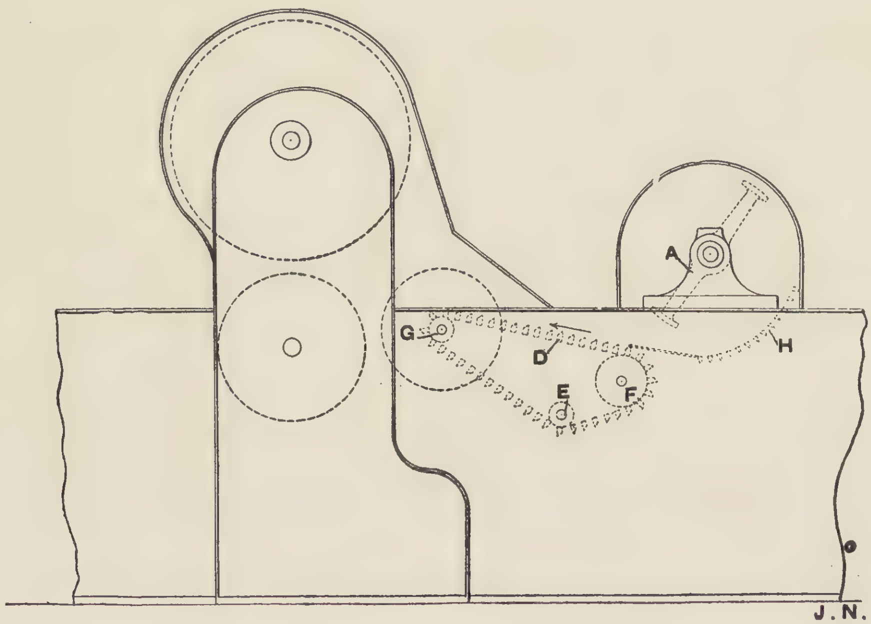


Fig. 26.

meets the cotton as it passes from the beater. It is kept in tension by means of the rollers E F and G, and as the bars pass over E, which is unattached, its weight causes them to open, and so drop the leaf into the chamber below. Having thus described the mechanism of this special arrangement, it is necessary to say something of the draught regulation and the effect it has upon the work.

(78) The regulation of the air current is one of the most important features in the working of a scutcher. Other things being equal, it is not too much to say that success or failure largely depends upon it. On the one hand, it is necessary to provide sufficient suction to draw the cotton forward and lay it evenly on the cages ; on the other, an excess of suction is very detrimental, as, if the movement of the cotton is too rapid it will be drawn over the dirt grids *before* instead of *after* the dirt and leaf has fallen. More especially for the sake of the removal of leaf does the current require to be slow. With any other procedure the lighter matter cannot fall, and is carried

forward to the cages. An excess of suction further results in the cotton fibres being drawn into the interstices of the cage surface, and the fleece does not in that case leave the latter easily. This results in a rough surface of the lap, and leads when it is rolled up to "licking," or adhesion of the different layers.

(79) It is therefore desirable to get the draught as nearly balanced as is consistent with the required onward movement of the cotton. What is wanted is rather a large volume of air moving at a slow pace than a smaller one travelling more quickly. The fan should therefore be as large as can be conveniently arranged, and should be run at a comparatively slow velocity. Its exit orifice must be of ample size, and no obstruction be presented to the current of air. The latter is delivered into a passage or conduit running below the floor and terminating either in the open air or a specially-arranged chimney. All these passages must be made of ample size, and cases are numerous in which neglect of this requirement has resulted in the inefficient working of a machine which otherwise ought to have worked well. The atmospheric changes render it necessary to watch the regulation of the current so as to suit them, within limits.

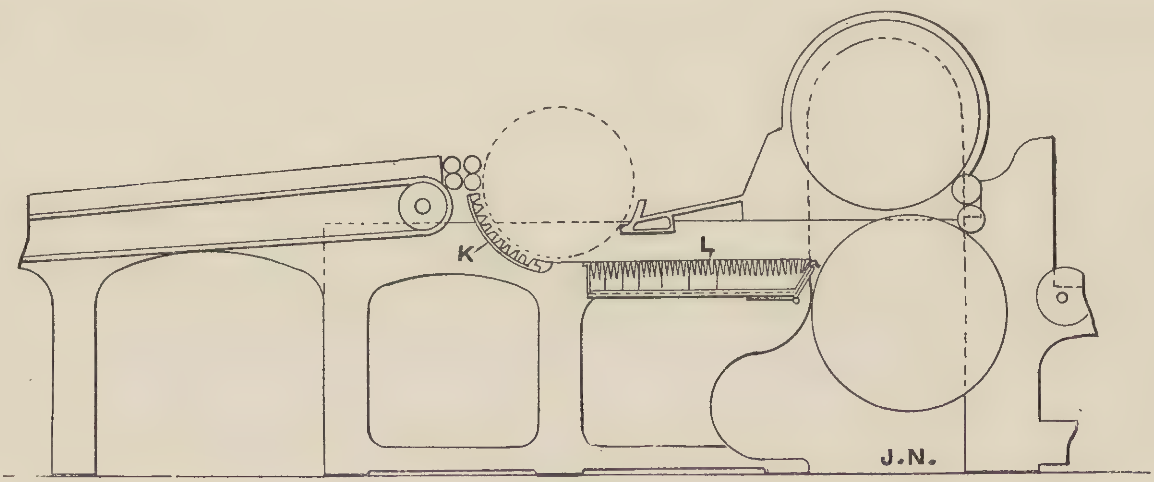


FIG. 27.

(80) The precise effect of the arrangement of the dead-plate and beater-sheet referred to in paragraph 77 is to decrease the work thrown upon the fans. The beater, by reason of its rapid rotation, creates a sufficient current to carry the cotton on to the grids or extractor, if the space between the dead-plate and sheet is narrowed as described. If that be increased the effect of the impulse thus given is diminished proportionately. When so arranged, the cotton impelled as described passes gently over the leaf extractor, being aided by the slow current created by the fans, and thus allows the leaf to fall freely and without difficulty.

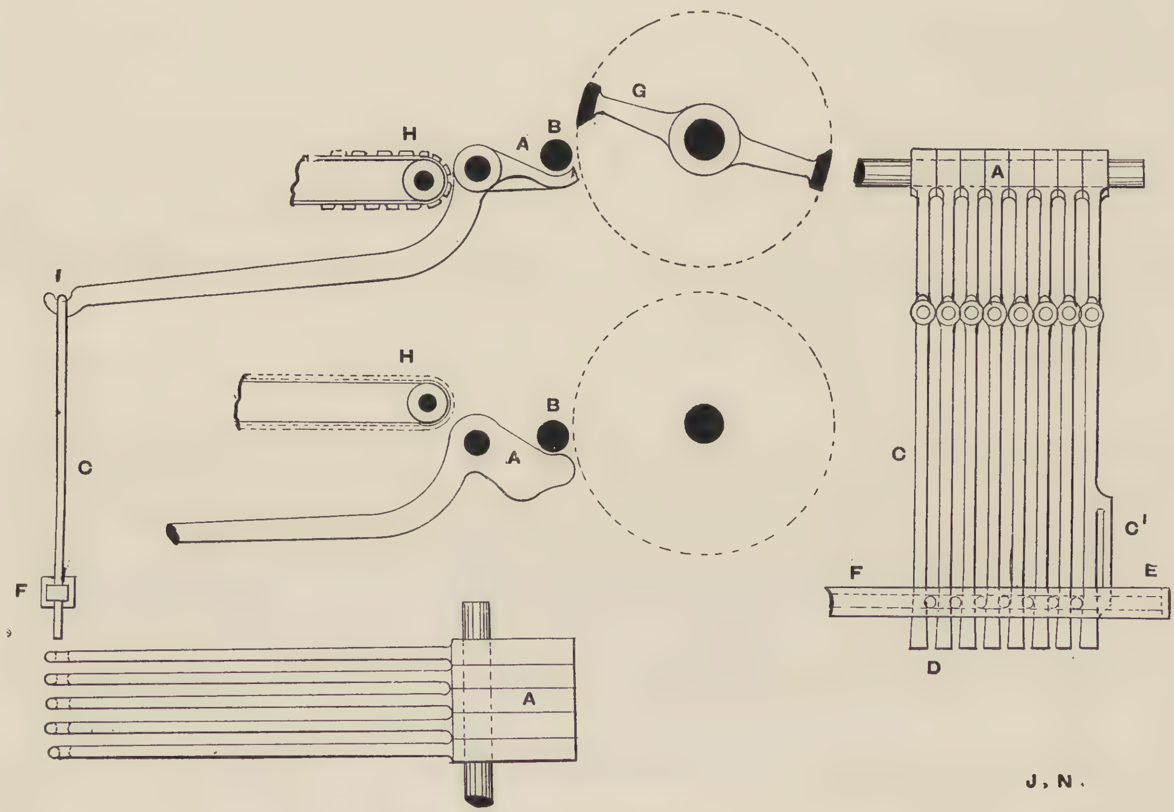
(81) In Fig. 27 a diagrammatic representation of Messrs. Platt Brothers and Company's arrangement is given. In this case, also, the dead-plate is arranged so as to narrow the exit orifice from the beater, with a similar beneficial effect to that described. The cotton then passes over the bars of a dirt box L, into which the leaf can fall, being periodically removed.

(82) The feed apparatus used is now almost universally combined with a regulator which bears the name of its inventor, the late Mr. E. Lord, of Todmorden, and is commonly known as the "piano feed." It is one of the most effective motions in the whole range of textile mechanics, and has considerably increased the regular working of this particular machine. Referring now to Figs. 28 to 31, which are respectively side, end, and plan views, it will be seen that the cotton is fed from the lattice H over the nose of the pedal lever A and under the feed roller B. After this it is struck by the beater G in its rotation. The shape of the pedal nose varies considerably, according to the length of the cotton used, the modification in Fig. 28 being that used for short, and the one in Fig. 29 being employed for long stapled cotton. The pedal lever is hinged upon a rod, and has behind its fulcrum a long tail piece which terminates in a hook I. On to this a pendant lever C is suspended. The lower portion of each of these pendants is widened so as to form a double taper surface, as shown in the end view at D. Between each pair of pendants, at its lower end, small runners or bowls are placed, these being fixed in rods sliding in the double frame F, which at the end E is tied together. The last of the series of pendants C^1 is formed with a slot, as shown, with which a lever is jointed, as will afterwards be described, and as is further shown in Fig. 23, which is an end view of the machine shown in Fig. 22. All the pendants can swing freely upon the pedal levers. The latter are placed, as shown in the plan, in close proximity to each other, so as to cover the whole space below the feed roller, while at the same time they have freedom of movement.

(83) Referring now more particularly to Figs. 22 and 23, the last pendant lever is coupled by the connecting rod O and the levers shown to the two strap levers E, which have sectors formed at one end gearing with each other. These levers carry the guides for the strap N, which is tightly placed upon the cones D D^1. These are respectively convex and concave, their outline being a parabola. The cone D^1 is driven by means of the strap shown from a pulley on a counter shaft, and revolves at a velocity of 600 revolutions. The other cone D is driven from D^1 by the strap N, and is fixed upon a spindle or shaft which is carried upward (Fig. 23). On the upper end of the shaft is a worm P engaging with a worm wheel R on the feed roller, which is driven by these means, or a change wheel may be interposed if desired.

(84) The action of this mechanism is as follows. As the cotton is delivered by the lattice it passes over the nose of the pedal and between it and the feed roller. If there happens to be a thick piece in the feed it depresses the nose of the pedal over which it passes. This raises the pendant rod C. Now the space between the thinnest portion of the pendant foot and the bowls is only sufficient to enable the pendant to rise a little before pressing on the bowl next it. Its motion being limited in this way, and the tendency to rise still occurring, either the pendant must become jammed or the bowl must have liberty to move to one side. This is what occurs, the lateral movement of the bowl being permissible to the extent which corresponds to the space between the remaining pedals and their adjoining bowls. After this is taken up, pressure exercised by the rising pendant upon the bowl causes the bar in which the latter is fixed to move in the box to an extent which is regulated by the depression of the pedal nose. In other words, the pendant swings on the end of the pedal lever either to the right or the left as may be required, giving a similar movement to the

rest of the series. The movement thus set up is communicated to the strap levers E by means of the connecting rod O and its attachments, and the strap is accordingly raised or lowered as required by the circumstances of the case. The weight of the parts connected to the pedal levers are sufficient to press their noses against the feed roller unless prevented by means of the cotton being fed. Thus a thin place in the material at any part of the width of the feed roller is followed by the reverse action to that named, the strap being moved on the cones in a similar manner. The presence of a thick place in the feed



FIGS. 28, 29, 30, AND 31.

decreases the velocity of the driven cone and feed roller, while the reverse action occurs when a thin place is presented. Thus the retardation of the cotton in the one case leads to any extra thickness being rapidly beaten out, more blows being given to the same length fed than would be under ordinary circumstances. On the other hand, a thin place results in the quickening of the feed roller and a greater quantity of cotton is beaten off in the same time. In this way an evenly-weighted delivery takes place, and this, in conjunction with the lap feed, of which more will be said hereafter, enables a lap to be finally produced, in which the variations of thickness are comparatively slight.

(85) At one time it was the universal custom to strike the cotton directly from the pedal nose Fig. 32, a practice which, however the latter was shaped, had many defects. A much better method is adopted by Messrs. Platt Brothers and Company, and is shown in Fig. 33, which illustrates the new practice. It will be seen that, when the beater strikes the cotton directly from the pedal nose, the fibres will be bent sharply round an angle. In the case of long-stapled cottons especially this is detrimental, as it is liable to lead to rupture or breakage of the fibre. With the shorter-stapled varieties this is not so likely to occur, and the use of a pedal and feed-roller is more permissible. The arrangement shown in Fig. 33 is a much better one, and consists in the employment of an additional pair of feed rollers placed between the pedal and the path of the beater. There are two distinct advantages from this procedure. The cotton is bent round a larger curve when it is

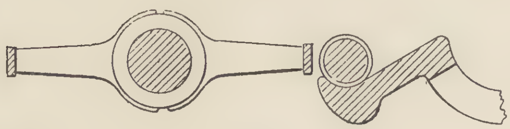


Fig. 32.

Fig. 33.

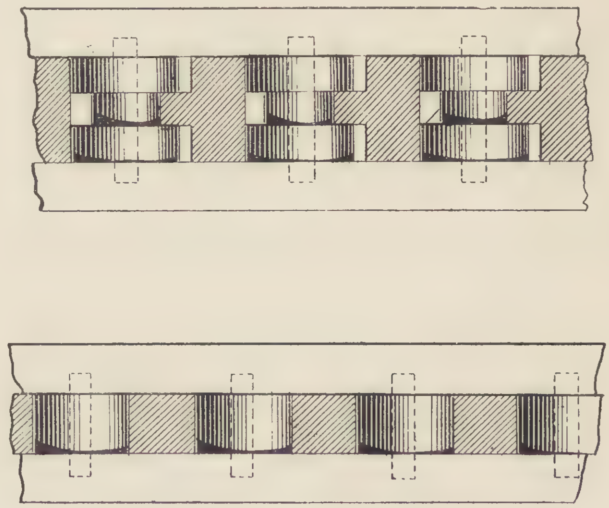


Fig. 34.

struck by the beater, and is, therefore, less liable to rupture; and the feed-rollers exercise a certain amount of drawing action. The latter point is of some value. The cotton in passing under the feed roller and between it and the pedal nose is held by them. The correction of thick or thin places and the alteration of the speed of the feed to meet them is controlled from this point. If the second set of rollers revolves at a slightly quicker speed than the one above the pedal the cotton will be a little drawn. In any case, this action will take place to a greater or less extent, and the thick places will thus be partially thinned out before being struck by the beater. The shock of the stroke is thus considerably diminished, and the risk of damage much lessened.

(86) It only remains to be said with regard to the Lord pedal motion shown in Figs. 28 to 31 that it is now amended by the introduction of two bowls between each pair of pendants, which are acted upon singly by the pendant they adjoin. The latter point is illustrated in Fig. 34, which represents the old method of arranging the pendants and rollers, and an improved plan of Messrs. Howard and Bullough. In the former case each pendant engaged with one side of a bowl, with the other side of which the adjoining pendant also engaged. In the event of

both of the latter rising at once, it is apparent that the bowl will tend to be rotated in opposite directions. In effect it becomes practically inoperative, and the friction set up is considerable, preventing the easy movement of either pendant. To obviate this, the three-bowl arrangement shown in Fig. 34 is adopted. The pendants are made with one flat face, and with one on which a rib is formed. On the spindle three bowls are placed, the centre one being of smaller diameter than the others. The two outer bowls engage with the flat side of one of the pendants, but are entirely out of contact with the adjoining one. On the other hand, the central bowl engages with the rib formed on one pendant, but is too small in diameter to engage with the flat face of the next of the series. Thus the whole of the pendants could rise simultaneously without setting up the friction referred to owing to the cross torsion on the rollers. The sensitiveness of the motion is thus largely increased. The adoption of two bowls, each independent of and out of contact with the other, produces a similar result.

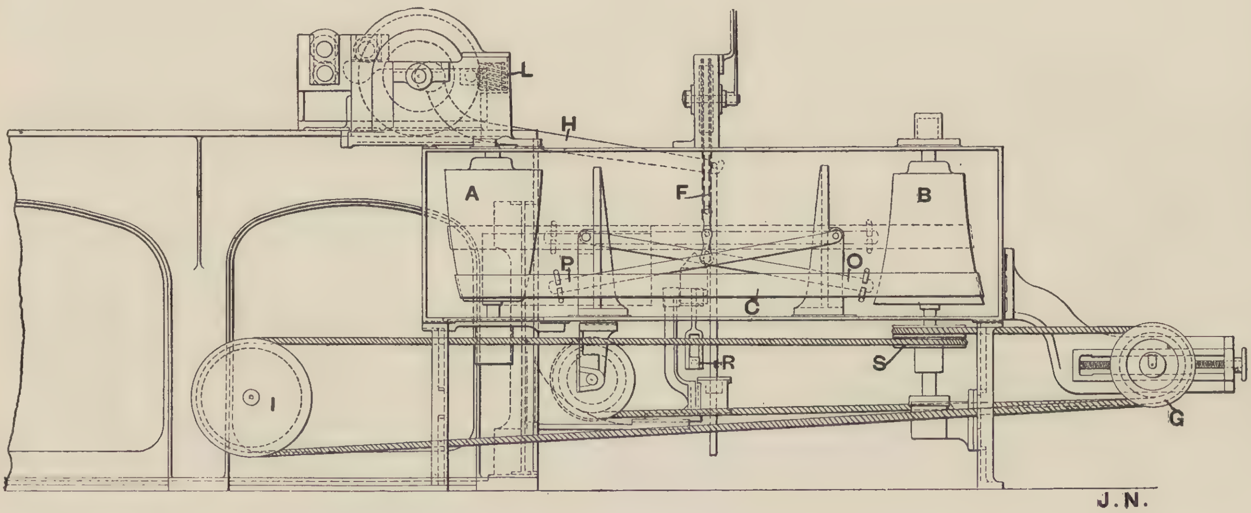


FIG. 35.

(87) There are several modifications of the pedal motion in use, but, before passing on, the arrangements used by Messrs. Platt Brothers and Company may be described. Dealing first with the driving of the cones reference may be made to Fig. 35. The spindle of the driving cone B is prolonged so as to rest in a footstep and has fixed upon it the double-grooved pulley S. An endless rope or band is passed round the pulley I, which is the driving pulley, and thence passes round the pulley G, carried on a pin, the position of which can be regulated by the screw shown. After going once over the pulley G the band is conveyed round the upper groove of the pulley S, back to G, thence to the carrier pulley shown, again round S, and finally returns to the driving pulley I. A little consideration of the course thus followed will show that there is a pull upon the spindle of the cone B in diametrically opposite directions, and as the pull is in each case equal, the wear of the shaft and footstep is materially reduced. The consequence is that high velocities can be attained with the utmost ease, and without any undue strain upon the ropes or shafts.

(88) Referring now to Fig. 36, which is a front view of the pedal arrangement, it will be noticed that the levers P are each of them placed between two bowls, which are actuated by their own pendants only.

Instead of coupling the regulating levers to the last of the series of pendants, a different arrangement is adopted. The hanging lever O is fastened at its upper end on a pin carried by the horn bracket shown, which is fixed to the bowl box. On the other end of the pin is a second lever, shorter than O, and also fixed to the pin. Thus any oscillation of the lever O is followed by a similar movement of the second lever. The lever O is long enough to enter the bowl box, and any lateral movement of the bowls causes a similar movement in the lever. This is repeated by the shorter lever, which is coupled to a connecting rod Q. The latter is made in two parts, connected by a nut, with a right and left handed thread, so as to permit of any adjustment necessary, which is also aided by the slots shown as existing in the various levers in the series. The rod Q is jointed to an L lever R, on the horizontal limb

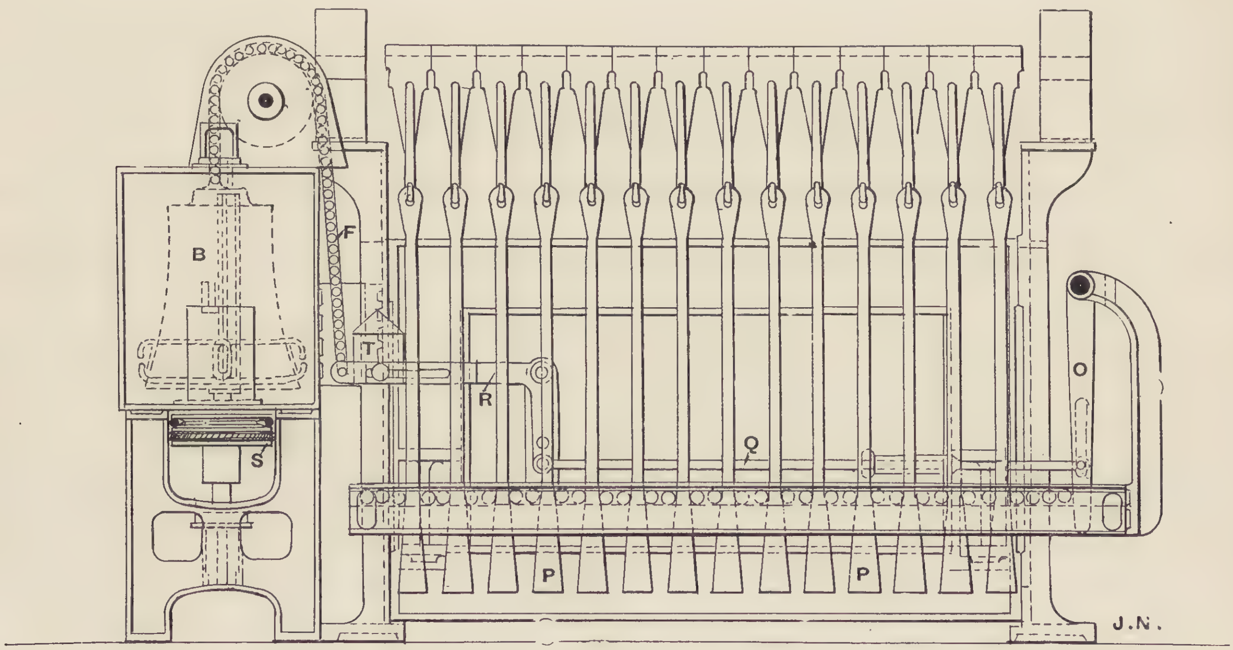


Fig. 36.

of which the balance weight T is fastened by means of a pin passing through the slot. To the extremity of this limb of the lever R a chain F is coupled, which, passing over a grooved pulley placed above the cone box, is attached to each of the strap levers O P (Fig. 35). These levers are hinged in the manner shown, and carry strap forks acting upon the strap C. The relative positions of the strap and levers, at a point midway of the length of the cones, are shown by the dotted lines in Fig. 35. On the spindle of the cone A is the worm L, by which the feed rollers are driven, the three roller arrangement being in this case used, one of them revolving above the nose of the pedal lever.

(89) The action of this mechanism is easily explained. As the pedals are depressed or elevated the bowls are moved laterally, as previously described. The last of the series being in contact with the lever O

causes it to oscillate, and, in consequence, the shorter lever jointed to the rod Q is moved. This motion is communicated to the chain F, which exerts a pull upon the strap guides, and raises or allows them to fall as described. One cardinal feature in this arrangement is the power of adjustment which is given at every point, the balance weight T being easily set to give the exact amount of pressure of the lever O upon the last bowl, while at the same time permitting it to oscillate without an excessive power being required. This makes the motion very sensitive, which is assisted by the size of the cones, and by placing the pedals on knife-edged supports instead of a shaft. Usually the cones are made about 4 inches diameter at the large end and $2\frac{1}{2}$ inches at the smaller. In the machine, as made by Messrs. Platt, the cones are 8 and 5 inches diameter respectively at each end, and, as their velocity is high, a slight pull upon the strap vertically is sufficient to move it up or down the cones.

(90) A special arrangement, made by Messrs. Dobson and Barlow, is shown in Figs. 37 and 38 in elevation and plan. Here the pedals W W^1 are all of the same shape, and the last of the series W is not coupled to a connecting rod, as shown in Fig. 22. Instead of this, three bowls, R R T, are placed upon a pin which passes through the forked end of the small frame Z. The rollers R R roll in the groove in the box, and are provided with broad flanges which keep them in position laterally. The roller T is in contact with one edge of the last pendant W, and when the latter is pushed to one side it presses upon the roller and causes it and the cradle Z to move in the same direction. A pin in the other end of the cradle passes through the end of a lever Y, which fits between the fork in Z and passes through a hole in the cross-piece of the bowl-box. The thrust upon the rod Y is therefore given in the centre of the pendants, and these are not liable to be twisted. The rod Y is jointed to the L lever shown, which forms part of the series connecting the pedals and strap guide levers. As shown in the detached sectional view, Messrs. Dobson and Barlow employ between each pair of pendants three anti-friction bowls, U V U, which work loosely upon the pin X. The latter is made in the centre with a boss, eccentric to its main portion, and in this way the central bowl V is caused to engage with the pendant W, while the other two U engage only with the pendant W^1. The pin X cannot revolve by reason of being fitted into a square hole in one of the bowls sliding in the groove in the box, so that the relative positions of U and V are always maintained.

(91) In Figs. 39 and 40 a front and side elevation of the pedal regulator as made by Messrs. Asa Lees and Co. Limited, is illustrated. The pedals E are hinged at one end, and rest upon vertical rods J, the lower ends of which press on the extremities of the balanced plates B. Each of these is suspended on a larger plate C, of similar construction, which in turn rests on the extremity of a plate D. The latter is suspended by its centre from a lever, F, which is fulcrumed on a knife edge at H. The lever F is coupled in the manner shown to the strap guide lever I, which is moved by means of the horizontal bar shown, which slides upon guide runners. The cones A A^1, are placed horizontally, the advantage claimed for this position being that the strap has a much easier motion along the cones than is the case when the latter are vertical. It will be observed that the whole of the balanced plates are in equilibrium, and are suspended on the end of the lever F. Thus a slight movement of one of the smaller plates, B, is multiplied before it acts upon the lever F, and the regulation of the strap is thus rendered more sensitive.

(92) In Fig. 41 a side elevation of the driving gear used by Messrs. Asa Lees and Co. is shown. In this case the whole of the essential movements are driven by means of one endless rope. This plan obviates the difficulties which arise if a beater strap breaks and the feed continues, or if the delivery ceases from the same cause and under the same circumstances. In this case the lap attachment and cages are driven from the pulley D, the beater and the cones also by the same rope. The direction of the rope's movement is indicated by the arrows, and a tightening screw is provided to keep the band in tension. On the shaft of the beater is a friction clutch, one-half of which is formed into a grooved pulley. By disconnecting the clutch, the beater can be stopped independently of the rest of the machine.

(93) Having thus described the principal methods of arranging the mechanism adopted by various machinists, there are one or two words to be said with reference to combined machines. These are very numerous and various, being arranged in several ways to suit the requirements of particular spinners. For instance, in Fig. 9,

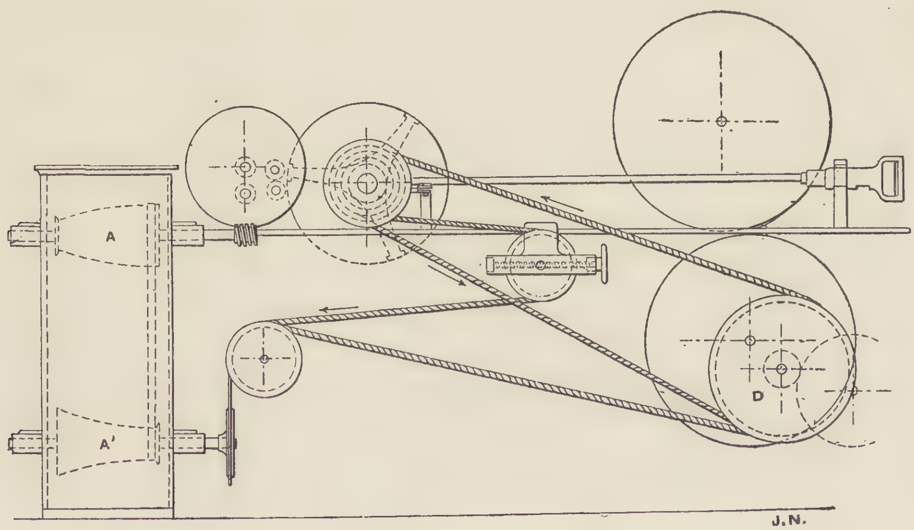
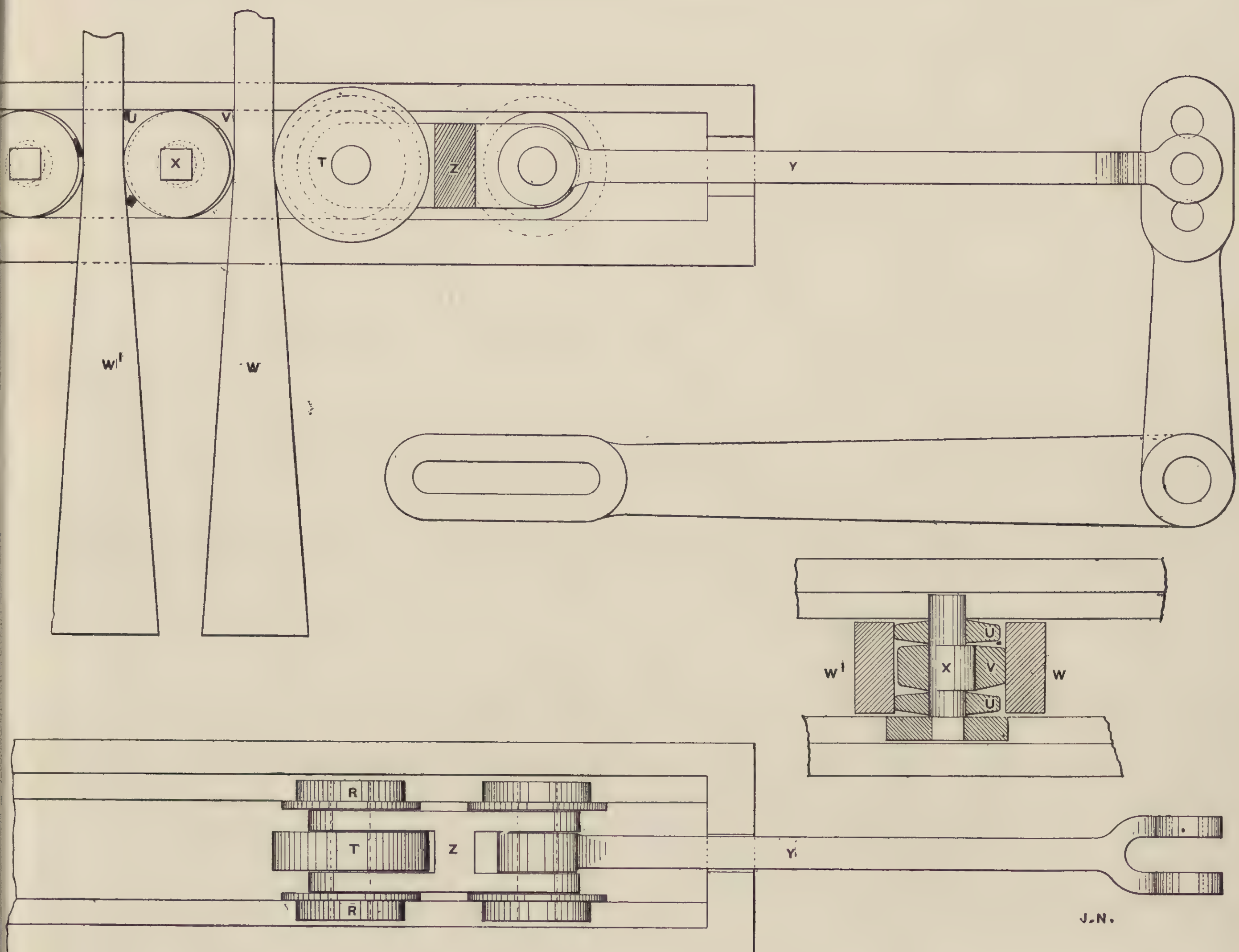


Fig. 41.

described in the last chapter, there is a combined machine, viz., an opener and lapper. The machine shown in Fig. 20 is an instance of a combined opener, scutcher, and lap machine. So, again, the machines shown in Figs. 13 and 14 are similar combinations, and in Fig. 8 is an example of a breaker feed combined with an opening cylinder—in different rooms but coupled by an air pipe—used as an aid in forming a stack of mixed cotton partially cleaned. In Fig. 13 a representation of the arrangement of a scutching room with a mixing room above it is given in section, and in Fig. 42 a plan of the mixing lattices. In this the bale breaker A delivers the cotton to a double ascending lattice B by which it is transferred to the series of longitudinal aprons C. Openings are placed above each bin E so that the cotton can be discharged into any of them at will. Alongside the mixing bins is a longitudinal lattice F, on to which the cotton is placed as it is taken from the stacks, and is carried to the porcupine



FIGS. 37 AND 38.

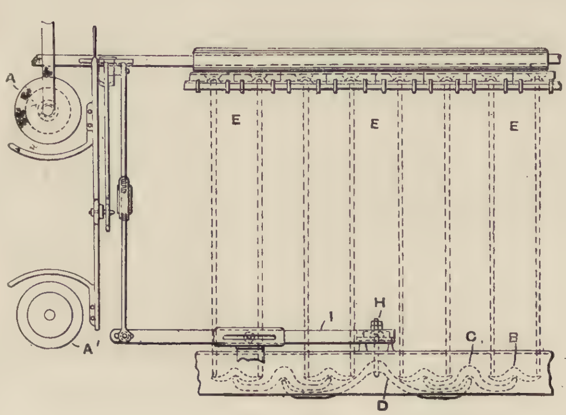


FIG. 39.

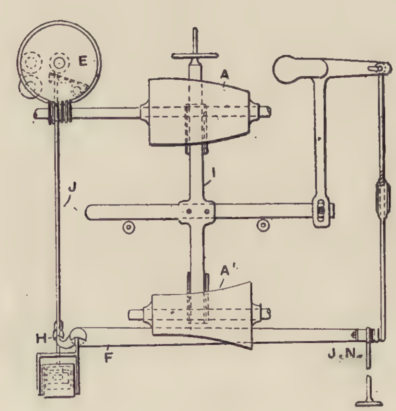


FIG. 40.

feed table G. Immediately after being treated by that machine the material passes into the dust trunks D, over the dirt grids at K, to the cylinder of the opener H. The laps there formed are placed in the scutcher L, and those made in that machine are fed to M. The laps formed on the opener are fed to the scutchers, as shown in Fig. 22. In Fig. 43 a plan is given of one arrangement of a scutching room, showing a complete set of machines for dealing with Indian or other dirty cotton. For long stapled clean cotton, such as Egyptian,

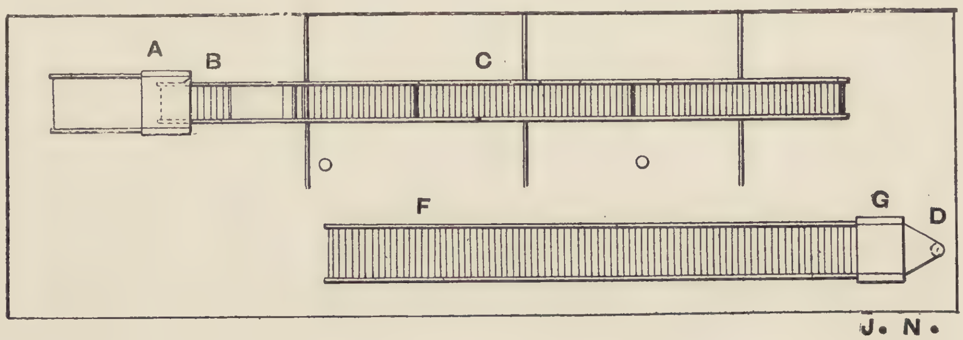


Fig. 42.

only the two machines enclosed within the dotted lines are necessary. Most of the figures dealing with these combinations are representations of actual arrangements carried out by Messrs. Platt Brothers. It is obvious that some plan must be adopted by which the supply of cotton must be stopped when the scutching machine is knocked off. If this was not the case, the air tubes and dust trunks would speedily become full, and there would be the risk of a breakdown when the machine was re-started. In view of this

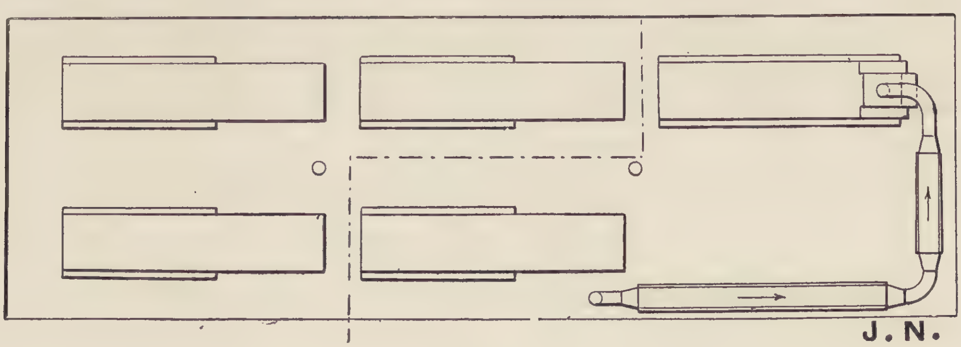


Fig. 43.

difficulty, Messrs. Platt arranged that when the machine is being stopped, the porcupine feed roller is stopped so much before the opener cylinder that the whole of the cotton delivered by it is drawn out of the dust trunks. Conversely, when the machine is being re-started, the feed mechanism is the first to begin operations, so as to ensure an ample supply of cotton to the cylinder, and thus avoid any thin places or failure in the resultant lap. This is a matter of some importance, as upon it depends very largely the regularity of the laps.

(94) It is of extreme importance to produce laps at an early stage, as they play a great part in effective spinning. Before dealing with this point a few words may be said about the necessity for care in feeding the cotton. The fibre is easily ruptured, more especially at the points, which, owing to their distance from the seed during growth, are often solid. It is conceivable that the cotton might be fed at precisely the same speed as that of the periphery of the beater blades. In that case it would simply pass through the machine without any treatment whatsoever. Or it might be fed so rapidly that the beater in its rotation would knock it off the end of the lap in tufts or lumps. As the blow of the beater is given transversely of the fibre, such a treatment would produce a large amount of broken fibre. It is, therefore, of importance to feed so that the cotton is neither broken by overfeeding or pulverised by underfeeding, and in fixing the right velocity the length of the fibre requires carefully taking into account. The conditions of successful and economical work are well known, and may be stated as follows: The blow given must be sharp, and not dragging; the beater blades must be shaped to detach, without rupturing, the fibres; the rate of the feed roller must be regulated to insure the thorough detachment of the material; and, finally, the cotton should not be struck from a sharply angular surface. It is, of course, impossible so long as revolving beaters are used to avoid bending the fibres, but it is quite possible to so shape the surface from which they are struck as to minimise the risk of damage.

(95) The various illustrations given of both opening and scutching machines show that it is the practice to form the cotton at as early a stage as possible into a lap. Not only is this course more convenient, but it is decidedly preferable where good work is required. In cases where it is the custom to eject the cotton from the opener in its opened condition, it is necessary to lay it on the feed lattice of the scutcher, either manually or by means of a lattice. A practice which is now almost obsolete is to weigh the cotton by means of scales adjoining the feed apron, and spread it on the latter by hand. Even with expert attendants, the risk of uneven feeding by this plan is great, and uneven feeding means unevenly-weighted laps as a result. By the exercise of a little care, and more especially if the piano-feed be fitted to the opener, a lap it produced on that machine the inequalities of which are much reduced. The author recently saw a lap, paragraph 52, produced on the combined feed, opener, and scutcher of Messrs. Platt, which was the first made on the particular machine employed, and which was remarkably regular in thickness. The same result has been seen in other cases, and by obtaining a regular sheet at this early stage many advantages arise. Whether an opener be employed in conjunction with a breaker scutcher or not, the formation of a lap is a great help to good work. Where such a combination exists, it is customary to fit pedal regulators immediately before the scutcher beater is reached, so that the inequalities existing in the sheet as it is taken from the first pair of cages are at once corrected. A reference to Figs. 10 and 20 will show this application fitted respectively to the opener feed and the scutcher beater.

(96) Whatever may be the practice with regard to the opener, the breaker scutching machine is invariably provided with the lap attachment, and the finisher scutcher is fed from laps. A reference to Fig. 22 will show that the machine is fed from three laps F, which are laid upon the travelling lattice apron G. The forward movement of this lattice unrolls the laps and delivers them to the feed rollers, they being prevented from moving forward by

the rods through their centres, which press against the vertical projections on the lattice frame. It is often customary to use four laps instead of three, especially in passing them through the last machine.

(97) It will be apparent on reflection that the laps as produced will vary considerably in weight and substance. When first formed, and taken from the machine, each lap is weighed, and a record kept of its weight. In selecting the laps from which the finisher scutcher is to be fed, regard is paid to these variations. If one or two laps are under weight to a certain extent, while others are over it to a corresponding amount, the machine is supplied with both. As they are all fed at the same time, it follows that to a large extent the irregularity existing in one is corrected by the converse irregularity of another. This is, of course, a matter of degree, but roughly speaking, the correction is an effective one. By this system of doubling, as it is called, and by the regulation afforded by the pedal motion, the lap produced finally has rarely more variation than 5 per cent, and in many cases the variation does not exceed $1\frac{1}{2}$ per cent.

(98) There must be with a machine fed from four laps, as there is even in the opener, a considerable amount of draught existing, for it is obvious that the resultant lap will be no heavier than one of those fed, and is in most cases lighter. That is to say, the lap is elongated so that an equal length of the finished lap weighs less than that of those fed. Thus the irregularities of thickness existing in any of the laps fed to the machine are diminished by the draught of the machine, and when this factor is combined with that arising from the treatment of four laps together, the result is found in the regularity stated. It is desirable to get as many doublings as possible, and where very good work is required the material is passed through three machines before the final laps are produced. This part of the subject is so easily understood that it is not necessary to further treat it.

(99) A point which is almost as important is the necessity for getting even selvedges to the laps when produced. The lap referred to in paragraph 52 had this feature, and there can be little doubt that the regulation of the air current plays an important part in this respect. It is of the highest importance that no thin places shall be found in the selvedges, as their effect is afterwards seen through every succeeding stage in spinning. Messrs. Platt Brothers have adopted a construction of their various machines, by which a gradually decreasing width is found in each of the series. Thus, if the opener produces a lap 48 inches wide, it will be fed to a scutcher 47 inches wide only, the lap so produced being that width. A similar or greater reduction is effected in the last of the series, the width being correspondingly reduced. In this way a very even selvedge is produced, with the consequent advantages.

(100) The weight of a lap is determined by weighing one or two yards. If it be afterwards desired to see what "hank" the lap is, the weight of the piece is obtained, and the weight of a pound calculated from it. That is divided into a constant number, obtained as afterwards described, and the resulting decimal gives the hank lap.

(101) The draught in a scutching machine takes place at the following points: 1st, between the feed lattice and rollers; 2nd, between the feed and the lap rollers.

(102) It only remains to be said that by the employment of air trunks and combined machines the finished laps can be produced by the aid of only two or three workpeople. The cotton requires no handling from the mixing room till the first lap is produced, and only then requires weighing and placing upon the finisher scutcher lattice table.

CHAPTER VI.

THE CARDING MACHINE.

(103) The scutching process being complete the heavy impurities are practically removed, but there are still to be found in the material the bulk of the lighter ones. The severe treatment of the cotton during scutching adds to the number of broken and short fibres, and also increases the neps. There are also still adhering to the material small particles of broken seed and leaf, which are technically known as "motes." The removal of all of these is part of the duty of the carding engine. In addition to this, it is requisite to arrange the fibres in what is practically parallel order, as only in this way can a strong yarn be produced. This object is attained by attenuating the "lap," and then treating its fibres by a number of fine wire points, so as to comb or card them. The objects of carding are, then, briefly stated, three-fold—the completion of the cleansing process, the parallelisation of the fibres, and the attenuation of the fleece.

(104) Cotton was originally carded much in the same way that wool was combed, viz., by drawing a hand comb through a mass of it while held on a table or bench. As soon, however, as the manual art of spinning was superseded by a mechanical process, a similar change occurred in carding. The earliest mechanical carding engine was invented either by Paul or Bourne, about 1748, and shortly afterwards Arkwright developed his roller carding engine, which, in its essential features, is identical with many machines of the present day. A full description of the early development of the carding engine will be found in Mr. Evan Leigh's work. The invention of the doffing comb, the revolving flat principle (by Jas. Smith, of Deanston); the coiler (by David Cheetham, of Rochdale); and the self-stripping card, all form stages in the growth of the machine. Latterly the attention of machinists has been directed to improving the mode of manufacture and the simplification of details, the main principle of the machine having been fixed for some years. All carding engines have a few essential parts which are common, and it will be better to give a general description of these before dealing with the details.

(105) The perspective view of a revolving flat carding engine, as made by Messrs. Ashworth Bros., given in Fig. 44 (page 63), will enable the description to be easily followed. The lap from the scutching machine is lifted by the iron roller on which it is wound, and the ends of the latter are slipped into the grooves formed in the brackets A. The surface of the lap rests upon a roller C, which is steadily revolved, and is geared with the feed-roller D. The sheet is drawn off the lap from the bottom, and is passed over a polished iron feed-table or plate, which at its inner end is dished. The feed-roller revolves in the curved part or dish of the plate, and is from 2in. to 3in. in diameter, being formed with longitudinal and circumferential flutes along its entire surface between the bearings.

(106) The projecting end of the lap, as it is delivered by the feed-roller, is thrust over the nose of the dished plate, and is struck by teeth fixed on the surface of a roller B, revolving at a rapid rate. The direction of the rotation of this roller is shown in Fig. 46 by the arrow. It is called the "licker" or "taker-in," and is made of cast-iron, keyed on a wrought-iron spindle, which revolves in bearings fixed to the framing. It is driven from a pulley on the cylinder shaft by means of a crossed belt. It is usually made 8in. or 9in. diameter, and the same width as the cylinder. Its surface is accurately turned, and it is covered when ready for work with a special wire clothing, to which further reference will be made in the succeeding chapter. The licker-in teeth strike off the cotton from the end of the lap, and carry it forward until it comes into contact with the cylinder teeth.

(107) The cylinder E is made from 40in. to 50in. diameter, and from 37in. to 50in. wide. It consists of a cylindrical shell, strengthened throughout its length by small internal ribs, and having near its edges a flange formed. Its position is clearly shown in Fig. 46, and the way in which it is built in Fig. 51. The inner part of the ends of the cylinder and the face of the vertical flanges are bored out accurately by a specially constructed machine. Into each of these recesses a spider is fitted, consisting of a central boss, arms U, and rim V. The boss is first bored to the size of the shaft upon which it has to fit, and the edge and inner face of the rim are turned to a size corresponding with the recess in the cylinder. The two spiders so prepared are fitted into their places, and are then securely bolted to the cylinder. In this way a firm and accurate fit is secured. A mandrill is fitted into the bosses, and the cylinder is then turned truly on its face. After the shaft is fitted in it is sometimes the practice to grind the face of the cylinder, but, if the needful care is taken in turning it, this is not necessary. It is essential that the periphery of the cylinder shall be rigid, but it is equally important that the latter shall not be too heavy. A velocity ranging from 140 to 200 revolutions per minute is given to it, and it is clear that lightness and perfect balance are alike important. After the turning is completed the surface of the cylinder is drilled with a number of rows of holes about half an inch diameter, into which wooden plugs are driven, so as to facilitate the "clothing" of the cylinder. As a rule the latter is balanced, or rather tested for its balance, by running it at its working speed in bearings which slide when the equilibrium is disturbed. When working, the direction in which the cylinder revolves is indicated by the arrow in Fig. 46, and the cotton is carried from the licker-in B to the doffer F, being treated on its way thither by a special set of teeth, the arrangement of which will be hereafter described.

(108) The doffer is a cast-iron roller, 22in. to 26in. in diameter, the same width as the cylinder, and is placed as shown at F. The doffer is constructed and clothed in a similar way to the cylinder. It revolves, as shown by the arrow, in the contrary direction to the cylinder, and at a much slower rate, making usually about twelve revolutions per minute. In this way the carded fibres are transferred from the cylinder to the doffer, and are placed on the surface of the latter in a thin fleece. The removal of the latter is effected by a narrow thin steel blade G, Fig. 44, known as the "doffer comb," which is fixed on the ends of short arms fastened on a shaft carried by bearings at each end. A rapid oscillatory motion is given to the

comb by means of an eccentric or cam, driven from a pulley on the cylinder by a cord or band, the number of beats per minute reaching 1,100. An arc of about an inch long is described by it, and in this way a continuous fleece, called the "sliver," is taken off the doffer.

(109) The sliver is loosely gathered together into a strand by means of a specially shaped plate, and passed through a pair of calender rollers H Fig. 44 by which it is partially compressed. A slight traverse is sometimes given to the trumpet-shaped tube through which the sliver is taken to the calender rollers. After leaving the latter the sliver is taken upwards to an opening in the plate at the upper part of the frame I. This frame forms part of the apparatus known as the "coiler," which is illustrated in vertical section in Fig. 45.

(110) The coiler consists of a frame I within which is a vertical shaft V driven by means of the short horizontal shaft from the calender rollers. At the upper end of the shaft a second pair of bevelled wheels are geared, which drive the calender or feed rollers placed immediately below the trumpet-shaped orifice in the cover T, which is hinged as shown. One of the rollers is supposed to be removed in order to show the arrangement more clearly. The sliver entering by the orifice in T and, passing the rollers, is delivered into a short tube X forming part of the plate Z. The latter is driven in the direction shown by the arrows by means of the spur wheel Y gearing with a rack formed on the edge of the coiler plate Z. The sliver is thus given a slight twist, and is delivered into the can W, placed on a plate free to revolve and borne in the lower part of the coiler frame. The can is placed eccentrically to the coiler plate Z, and is slowly revolved in the opposite direction to it, as indicated by the arrows. In this way the sliver is laid within the can in coils, which are peculiarly disposed so that they do not become entangled. Often, within the can, a pair of discs, coupled by a coarsely pitched helical spring, are placed, upon which the cotton is received. The object of this device is to relieve the strain upon the sliver, which would otherwise arise if it were unsupported as far as the bottom of the can. As the weight comes upon the upper disc the spring compresses.

(111) The parts thus described are common to all cotton carding machines, and would remove the major portion of the motes and heavier impurities, but only a partial parallelisation of the fibres would occur; nor would more than a small portion of the short, broken, or immature fibres or "neps" be removed. It therefore becomes necessary to devise a means by which, while the cotton is on the cylinder, it may be treated so that the completion of the cleansing and the arrangement of the fibres are carried out. In order to do this the fibres must be submitted to a combing process, by which, while held by the cylinder teeth, another set of teeth act upon them. The form of carding engine which first found extensive employment, and which is yet preferred by many spinners, is known as the "roller and clearer card." This machine is illustrated in Fig. 47, as made by Mr. John Mason, in perspective, and in Fig. 46 diagrammatically. After the cotton has been taken from the licker-in B by the cylinder E it is carried past a roller J, known as a dirt roller. The diameter of this is from 5in. to 6in., and it revolves at about eight revolutions a minute. When the fibres are taken up by the cylinder wire, they are partially embedded in the interstices of the clothing, but the motes remain on the surface, from which they are easily removed. The dirt roller J takes these up, and,

being covered with a coarser pitched wire than E, the motes become fixed in the former, from which they can be stripped. This can be effected by a hand comb at regular intervals, or by an oscillating comb suitably operated in the way made by Messrs. John Hetherington and Sons, as illustrated in Fig. 48 (page 60). In this case the dirt roller A is driven by a side shaft by means of the worms B and D, the latter gearing into the wheel E, which is keyed on the dirt roller spindle. A cam F fixed on the first working roller gives a reciprocating motion to the rail G by which the comb H is operated, the roller J being thus stripped. An iron tray I is fixed, as shown, into which the strippings fall.

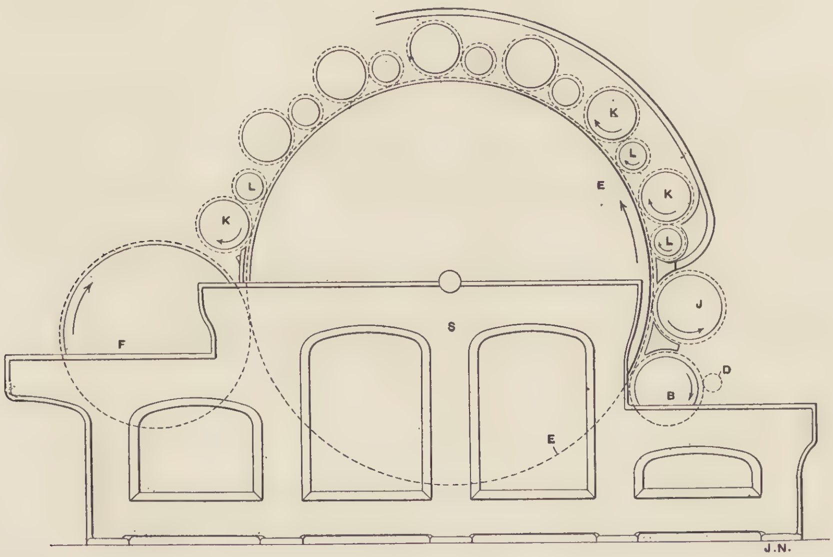


FIG. 46.

(112) After passing the dirt roller the cotton is treated by the teeth on a smaller roller, K, known as a "worker" roller, which revolves in the direction of the arrow. Each worker has a smaller roller, L, placed in contact with it and called a "clearer." The teeth on the worker have an inclination which is the reverse of those on the cylinder, and any cotton which is not fixed in the wire surface of the latter, or which is flung up by the centrifugal action of the cylinder, is seized by the worker teeth and removed. The worker revolves at a slower speed than the cylinder, its surface velocity being about 20 feet per minute, and varies in diameter from 5 to 6 inches. The clearer, which is 3 or $3\frac{1}{2}$ inches in diameter, has its teeth set in the same direction as its motion, and its surface speed being about 400 feet per minute, it takes the cotton from the worker and again transfers it to the cylinder. As the surface velocity of the latter is higher than that of the clearer, the cotton is struck by its teeth and is drawn off the clearer and carried forward to the next pair of rollers. It should be pointed out that, although the cotton on the cylinder passes the clearer before it reaches the worker, the inclination of the clearer teeth is such that they cannot take up the fibres; while, on the other hand, the worker teeth are so set that, as previously pointed out, they take up the fibres from the cylinder. Again, the different velocities

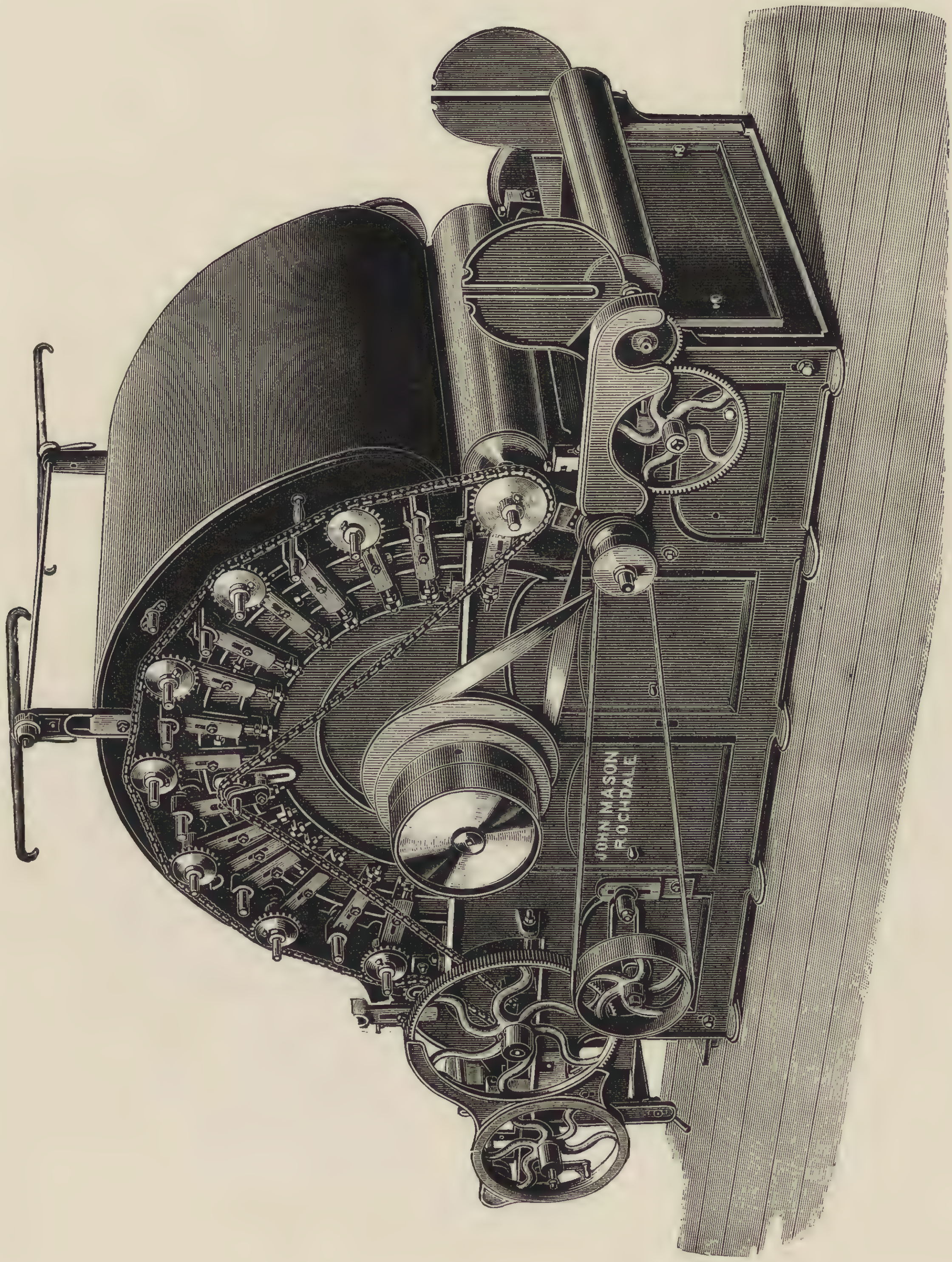


Fig. 47.

off the workers, clearers and cylinders cause a series of condensations and attenuations of the fleece to occur. The short fibres and "nep" are laid hold of, and are either sufficiently loosened to be thrown off as "fly," or are embedded in the teeth of the workers and clearers, which, in consequence, require periodical stripping, this being usually effected manually. The setting of the rollers must be such that they do not approach the

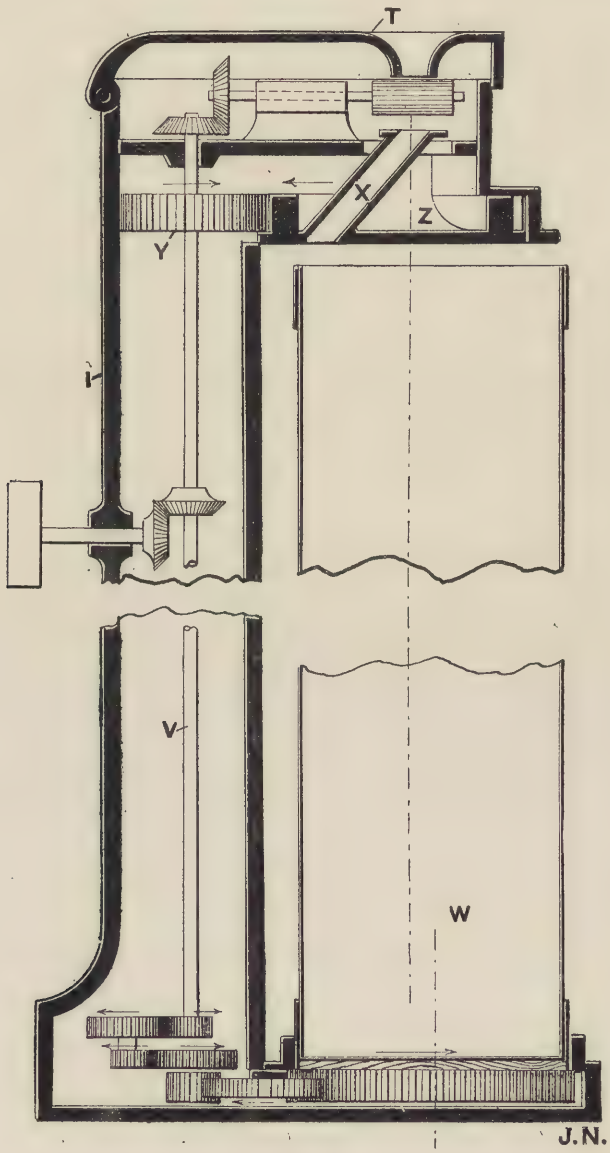


FIG. 45.

cylinder too closely, but simply deal with the fibres thrown up by the revolution of the cylinder. The lighter the carding, provided cleanliness is achieved, the better for the cotton, as with too heavy carding considerable damage is done to the material.

(113) The rollers and clearers are fitted with spindles, projecting beyond the cylinder and framing, and sustained by suitable bearings. On the projecting ends of both worker and clearer rollers, pulleys, with grooved peripheries, are fixed, over which an endless belt or rope is passed, deriving its motion from a pulley on the cylinder shaft. The worker driving pulleys are on one side of the machine, and those of the clearers on the other. The setting of the rollers is important, and it is necessary to make special provision for it. Fixed on the framework of the machine, forming the base S, Fig. 46, is a semicircular frame, which is known as the "bend." On this are fitted a number of brackets, the centre lines of which are radial to the cylinder centre, each forming a bearing for one end of the roller spindle. Mr. John Mason employs a special form, which is produced by planing the soles or feet of two of the frames, bolting them together and turning them on the edge.

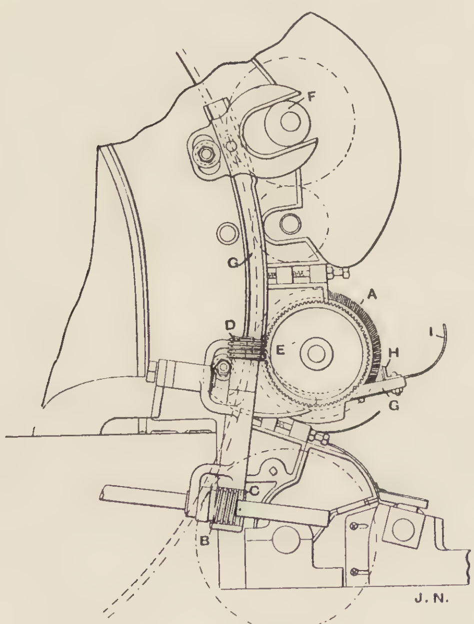


Fig. 48.

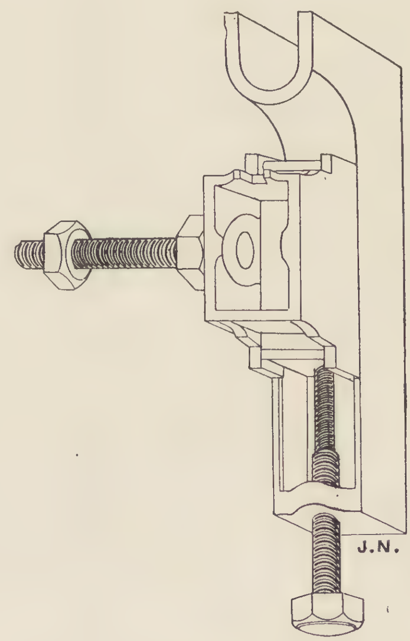


Fig. 49.

They are reduced to the required diameter to permit of the necessary setting, and when separated form half a circle. Each of these is bolted to the upper edge of the frame, S, which is planed to receive them, and thus a firm and accurate surface is provided for the roller brackets. The latter are constructed so that one portion of them can be set radially, or the whole bracket may be moved, if desired. Semicircular ribs are formed on the side of the bend, through which setting screws, locked on each side of the rib by nuts, pass. In this way the necessary setting can be easily obtained. As the machine is worked the wire points wear, and, when they are sharpened, the relative distance of the centres of the cylinder and rollers is not disturbed. In other words, the space between the points of the teeth on the rollers and those on the cylinder remains unaltered. It is absolutely essential that a definite distance shall be preserved, and means of setting the

rollers and clearers readily are imperative. This subject is treated at greater length at a later stage, when the revolving flat-card is described. A bracket made by Messrs. Lord Bros. is shown in Fig. 49, and it will be seen that ample provision is made for both lateral and radial adjustment.

(114) The whole of the worker and clearer rollers are covered by a case, as are also the doffer and licker-in. The emission of fly into the room is thus prevented, and its production materially diminished by the reduction of the disturbance of the air set up by the rapid rotation of the cylinder. The roller and clearer machine is often made with two cylinders, being then known as a "double" card. The cotton, after passing all the rollers placed above one cylinder, is transferred to the second by means of a small drum, similar in construction to a doffer, and known as a "tummer." The second cylinder bearings are fastened to the framing of the machine, which is made continuous, thus giving great solidity and strength. Double carding is undoubtedly effective in producing a good sliver, and is used in some cases where yarns of a good quality and as fine as 60's are spun. There has been, and still is, a controversy going on as to the respective merits of the various systems of carding, about which a good deal could be said. In the meantime it is sufficient to note that many spinners continue to put down roller cards in preference to some of the newer types.

(115) At the present time the "revolving flat" machine is the favourite one, and is being widely adopted. The peculiarity of its construction consists in the employment of a number of T shaped bars or "flats" extending across the top of the cylinder, and sustained at each end by the bend, or a plate attached to it. They are coupled by an endless pitched link chain, by means of which they are slowly traversed at a rate of about an inch per minute, in the same direction as the revolution of the cylinder. Referring now more particularly to Fig. 44 it will be seen that during the passage of the cotton from the licker-in to the doffer it is carried below the flats N, each of which has its underside covered with wire clothing. The chain passes round carrier pulleys, one of which is arranged to drive it, being itself driven at a regular speed in the manner shown. Each flat is thus carried over a certain portion of the circumference of the cylinder, and is then turned with its wire face upward. When this happens, an oscillating comb P strips the teeth, and they are then brushed out by the brush Q, usually formed with spirally arranged bristles, and sometimes made of wire. The flats vary in number from 89 to 110, of which there are from 40 to 50 always working. As they are specially constructed, it will be as well to describe the method of doing so at length.

(116) The flats are made of a T section for the greater part of their length, but have flat surfaces formed at each end, as shown in Fig. 51. On these surfaces they travel, and are sustained in their course by the bend. The width of each flat is usually from $1\frac{1}{8}$in. to $1\frac{3}{8}$in—the narrower ones being generally preferred—and the length varies with the width of the cylinder. The underside of each flat is made quite level, in order to afford a surface from which the various mechanical operations can be conducted. As the wire clothing is fastened to this face it is obvious that, by making it the base of all subsequent treatment of the flat, a decided advantage is obtained. The first operation is that of milling two surfaces at the upper side of each end of the flat, at the same time trueing up the faces of the ears to which the chain is attached. A double-

ended machine is used, fitted at each end with an instantaneous grip chuck, at the bottom of which is a steel face on to which the ends of the flat are placed, the flat having been previously stretched and straightened. The flat is then cramped down, and the cutter brought into operation. The flat is placed on the faces thus formed in the next machine, which is constructed with chucks at the end of two long radius arms. A cross spindle has a worm fitted on it, which gears with a segment at the end of the arms, and by revolving which the flat is brought under the cutters, and has a hollow cut into it of the desired radius. The flat is then chucked edge up and milled by a cutter on its upper side at the ends, so as to provide the necessary clearance for the chain. The next operation is to cut out, by means of a similar machine to the one with the long radius arms, the under surface of the flat end, which had been treated by that machine, so as to leave two surfaces on which the flat travels, the radius arms in this case being shorter. These surfaces have two objects—to lessen the friction when the flat is travelling, and to allow of the flat having the necessary heel given to it. The flat is then cramped down on the surface thus formed, and the snugs are drilled by a double-ended machine fitted with an automatic motion for withdrawing the drill. By the same machine the hole is tapped, the tap reversing when it has gone the requisite depth. After drilling the flat along the edges in order to enable the clothing to be fastened, it is complete so far as its treatment by machines is concerned.

(117) There are one or two things to notice in respect to the operations just described. The first is, that all the faces are formed from that on which the wire clothing is subsequently placed, and that consequently the flat when traversing is provided with working surfaces which ensure it being parallel to the cylinder all across, provided the bends are correctly set. This is, as will be seen, an important point. Again, the whole of the surfaces to which the chains are attached are true with the flat ends, so that there is no tendency to pull the flat askew. Having thus constructed, by the means indicated, the flat as perfect as is possible by machine, it is necessary to put the "heel" in, and also to correct any twist which may have arisen by the spring of the flat whilst being milled. There are two methods of testing this point, one mechanical and the other electrical. As will have been noticed from the description of the method of milling the flats, two parallel surfaces are formed at the upper and lower side of each end of the flat. It will be evident that, if the flat is placed upon either of these surfaces and tested by a suitable apparatus, the other surface should be as nearly as possible parallel with the first. In order to see that this is so, the flat is placed face downwards on two steel faces perfectly parallel with each other. At each end of the table carrying these faces is an indicating apparatus consisting of a graduated scale and two pairs of compound levers, so arranged that a slight inaccuracy is multiplied to a large extent. If, therefore, the flat is laid on the blocks and the points of the levers are allowed to fall on the four surfaces left after the flat is milled by the long and short radius machines, the setter can see at a glance if the surfaces are accurately formed. In practice, the two ridges or surfaces at the front of the flat—that is, the edge nearest to the doffer end of the card—are reduced somewhat by hand, thus throwing up the back edge. This is what is known as giving the "heel" to the flat, and its object is to leave a slight space between the wire points of the flats and cylinder at the back of the

flat, while at the front these are as close as possible together without touching. The object of this is to prevent a rolling up of the strippings and cotton fibre, which has been found to exist where the wire at the back or "toe" of the flat nearly approached that of the cylinder. The heel having been given the flat is then tested by the apparatus described, but instead of all the fingers corresponding, this only occurs with the two which are in contact with the same surfaces on each edge of the flat. One pair registers the variation caused by the heel and should correspond, while the other pair registers the position of the untouched surface and must also correspond. This device is the one most commonly used, and gives very accurate results. Messrs.

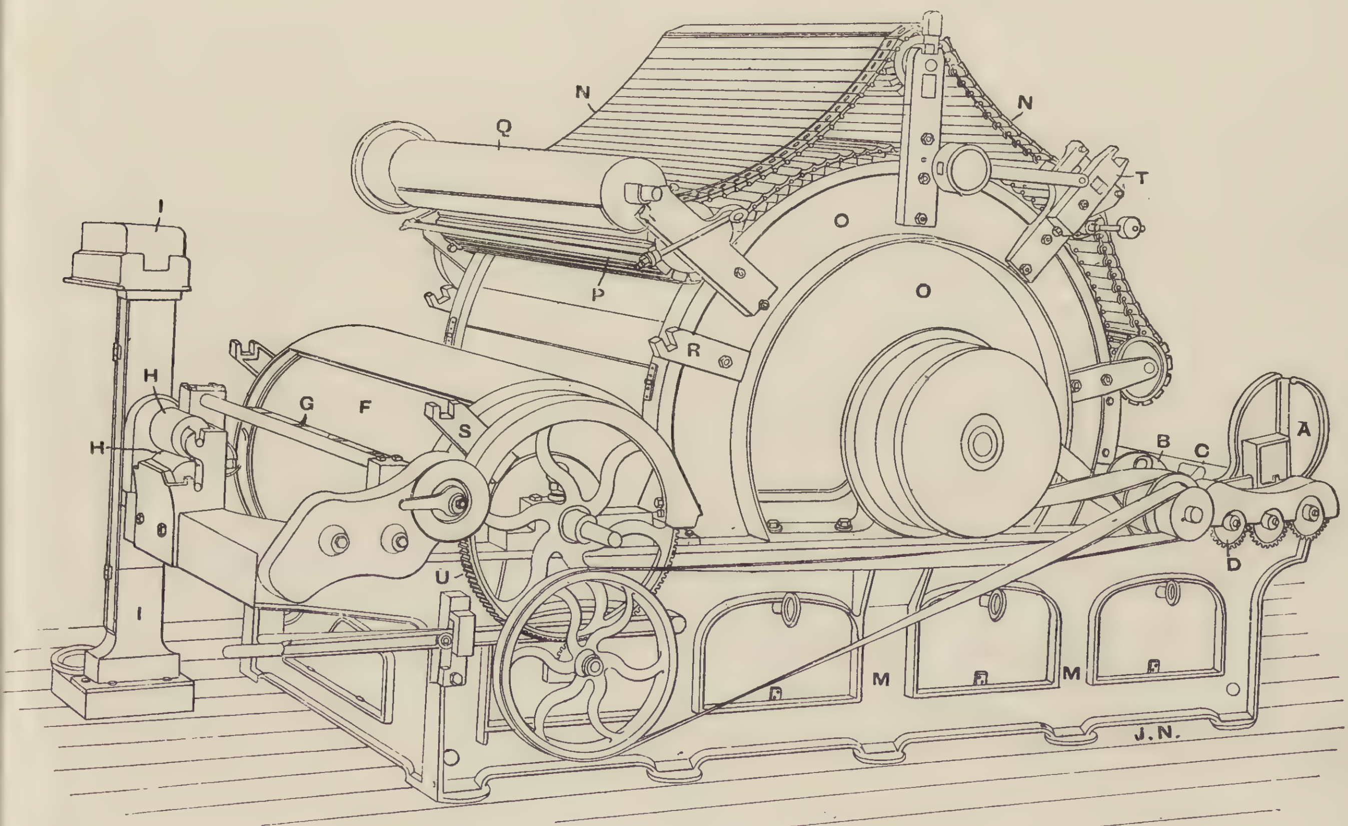


Fig. 44.

Howard and Bullough adopt an electrical test which is also said to give good results. Similar devices are used in some cases to set the bends accurately with the cylinders; in others a simple scriber or pointer being used and set down, so that a small slip of steel can be easily moved across the bend under its point. As the latter is carried in a bracket fixed to the cylinder the bend can easily be tested all round. Messrs. Howard and Bullough use an electrical scriber, contact with which rings a bell, and thus indicates the point requiring adjustment. The use of the graduated indicators as shown in Fig. 60 enables this to be easily made, and delicacy of adjustment attained.

(118) As the function of the flats is to remove by means of the wires attached to them the short fibre and nep, the more accurately the distance between the wire clothing on them and the cylinder is preserved, the better will be the effect produced. In order to attain this object it is necessary that the flats should be specially constructed and carried. A reference to Fig. 51 will show the construction of the flat, which is so finished (as was explained in paragraph 116) that the faces upon which it travels are parallel with the face upon which the wire is fixed. Thus, if the flat is borne upon a surface which is concentric with the surface of the cylinder, but so far from the centre of the latter as to compensate for the length of the wire on both, and provided that the two wire surfaces are accurately and evenly ground, it will be clear that over the whole of the surface there will be the same distance between the points of the wires. This is the condition which is absolutely the best for carding, but its constant maintenance is the problem. The flat course may be either formed on, or attached to, the frame O, and in either case is technically termed the "bend." This phrase is often very indifferently used, and is sometimes applied to the framing O when the latter is acting as a support for the flats, and sometimes to the surface attached to or borne by it for the same purpose. It ought, however, to be insisted on, for the sake of clearness and definiteness, that the phrase "bend" should only be applied to that portion of the mechanism upon which the flats actually travel. If it be assumed that a machine is in condition for starting for the first time, that the surface of the flat end upon which it travels is set back from the flat wire surface $\frac{1}{2}$ inch, and that the wire projects $\frac{1}{2}$ inch beyond the cylinder surface, there is a necessity for a circle with a radius of 26 inches. It is, of course, perfectly easy to form a track on the edge of the frame O, which should be accurately machined so as to be quite concentric and of the radius required, in which case the required distance between the two wire surfaces could be perfectly established. But, during the operation of the machine, the wire points become blunted and no longer deal with the cotton as efficiently as they ought. This necessitates their re-sharpening by grinding, which involves a reduction of the size of the circle described by the points of the cylinder wire, and an enlargement of that described by the covering of the flats. As has been pointed out, it is better that the two wire surfaces should approach one another as closely as possible without touching, the most effective results being obtained in this way, and it therefore becomes necessary to find some method of lowering the flats in order to re-establish these conditions. This is precisely the difficulty which has to be overcome. It is perfectly clear that any flat course formed on the frame O cannot be so adjusted, and it is essential that some other adjustable surface sustained by O shall be found. If for a minute or two the work to be done is considered it will be seen that there is a very difficult problem to solve. If a circle is struck 51 inches in diameter, and at the same time a second circle 52 inches in diameter is described, from the same centre, some idea can be obtained of the actual conditions of the case. Supposing that the circle 51 inches diameter is reduced to $50\frac{1}{4}$ inches (this representing the extreme variation in size arising from grinding), it will be at once observed that the dropping of the 52 inch circle in a radial line will be followed by the destruction of its concentricity with the other. In the case thus supposed the smaller circle represents the surface of the wire on the cylinder, while the larger one represents that of the ring upon which the end of the flats traverse. Now, while the

former is reduced with ease by grinding, the latter is not so easily reduced, and the action of moving it nearer the centre, without its reduction, simply means that its centre is moved to the same extent, while the centre of the ground surface remains constant. In other words, the concentricity of the two circles is destroyed. As the concentricity of the flat course with the cylinder is absolutely essential, in order to get that close approach over the whole of the wire surfaces which has been shown to be necessary, it follows that its destruction implies ineffective and bad carding.

(119) The arc occupied by the flats in their traverse varies from 120 to 150 degrees, speaking roughly, so that in some way or other a flat course of that length, capable of adjustment, requires to be provided. By far the most common method of providing this is to fasten to the side of the machine at the upper edge of the frame O a flat plate, shown in Fig. 50, with its upper edge forming a segment of the circle required. This arrangement is the invention of the late Mr. Evan Leigh, and has been widely adopted. The shape of this plate, so far as its depth is concerned, is so arranged that it can be sprung or compressed into a smaller circle with the minimum amount of difficulty and strain. This is what is known as a "flexible" bend, and is in wider use than any other form. It is attached to the frame side by bolts, slots being formed in the bend casting at each end through which the bolts pass. It will be seen that the slots allow of a considerable range of movement in the bend, which is made use of

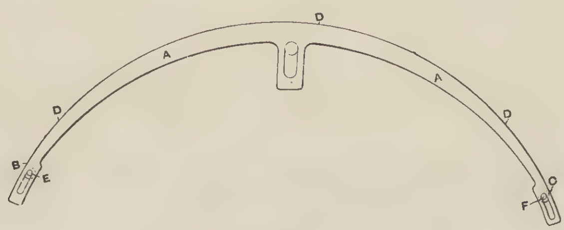
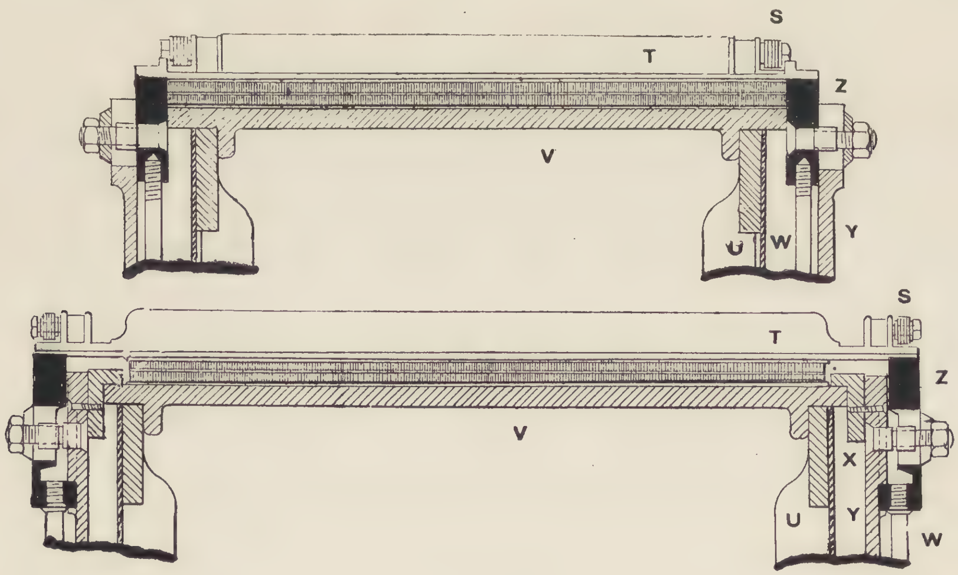


Fig. 50.

in setting it after the wire has been ground. The setting is effected by springing the bend by means of screws, until a circle is formed equal to that required to enable the wire surface of the flats to be concentric with the wire surface of the cylinder. As a matter of fact, the setting is done by the carder by sound and by the use of a gauge, the combination of which permits him to ascertain fairly accurately that the flats are in a good working position. When the bend is set, it is locked against the frame by the bolts, and stops, which are placed midway between the points of support, are brought up to the under edge of the bend. The object of these is to uphold the bend, so as to avoid deflection from the weight of the flats. As the cylinder, which weighs 9 or 10 cwts., revolves always in one direction at a steady rate of 140 to 170 revolutions per minute, and as the pull of the driving strap is usually towards the front, it will be perceived that a tendency, at least, will always exist towards wear in the brasses at their front side. Thus it is possible that in addition to the necessity for providing for the lessened circle, it may be also requisite to take into account the movement of the centre in a horizontal direction. The latter difficulty, however, has been to a large extent overcome by the elongation of the bearings, which are now much longer in proportion to the diameter than was the case formerly. The special construction of the bearings in order to resist the action of wear or to afford means of setting will be treated at a later stage in this chapter.

(120) It has been the ordinary practice to place the flexible bend outside the framing, but it is becoming the practice to decrease the width of the cylinder, and consequently the length of the flat. The cylinder is now ordinarily made 37in. wide when fed from 40in. laps, the lap being narrowed as it approaches the feed roller by specially placed and designed guides. By diminishing the length of the flat, the tendency to deflection is also lessened, and, in addition to this, an improvement occurs in the selvedge of the sliver. It will be seen that in diminishing the width of the lap 3 inches, it is only possible to do so by squeezing in its edges or folding them over somewhat. Thus any thin place on the edge of the lap is thickened, and the sliver when produced has a better selvedge. This advantage is partially derived by the means mentioned, but there is a further cause of ragged selvedges, to which a good deal of attention has been given. Usually between the edge of the cylinder and the bend a space has been left, through which, when the cylinder is revolving, a current of air is induced. As the cotton is held in the wire clothing, which comes right up to the edge of the cylinder, the suction thus caused draws it out and causes ragged places. Messrs. Ashworth Brothers remedied this defect by the employment of a circular shield about the height of the cylinder wire, which is fixed to and revolves with the cylinder. This gap is now entirely closed by all makers.

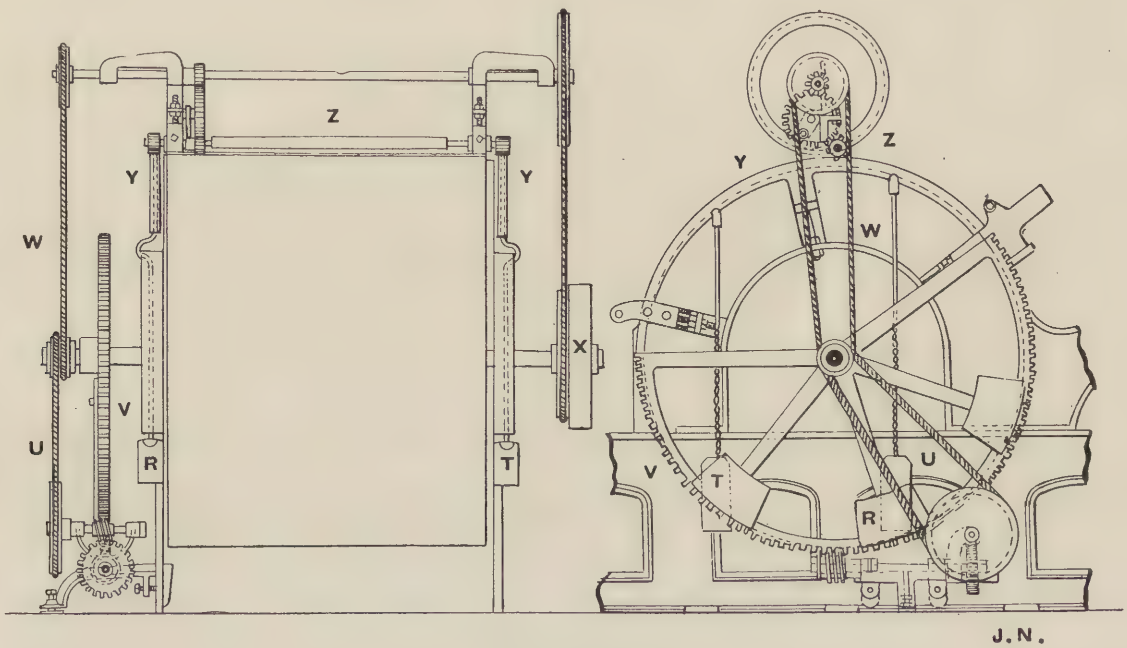
(121) Messrs. John Hetherington and Sons adopt the plan shown in Figs. 51 and 52, which are cross sections of the cylinder, bends, and flats. Fig. 51 represents the old method of construction. The flat T is sustained by the flexible bend Z, which is controlled by the setting screws W, and is attached to the



FIGS. 51 AND 52.

framing Y by the bolt shown. The cylinder V in this case is 40in. wide, and between it and the fixed bend a space is left, which is filled up by the introduction of the wood packing X. The latter is fastened to the fixed bend Y by screws as shown. The new plan is shown in Fig. 51. In this case the flexible bend Z is fastened on the inside of the framing Y, the setting screw W being placed as shown. It will be seen that the edge of the cylinder V comes close up to the bend Z, and no induced air current is possible. The cylinder

is reduced to 37in. wide as previously mentioned. The same firm adopt a very good method of dealing with the flexible bend, which is shown in Figs. 53 and 54 in transverse section and side elevation respectively. On the cylinder shaft a segmental rack V is fixed, which is driven by means of worm gearing, and the bands W U from the pulley X placed on the shaft. This also drives a spindle Z, borne in frames attached to the cylinder, on each end of which is a milling cutter. The cutters are kept in contact with the flexible bend Y, which is made a little larger than is necessary, and is bolted in its place after being accurately set. It is weighted with suspended weights R T, together equal to the weight of the flats when



Figs. 53 and 54.

resting upon the bends, and attached to the bends at points midway between those at which they are set. In this way the actual conditions of working are established as nearly as possible before the mechanism is started. On commencing operations the milling cutters are at one end of the bend, and the cylinder is slowly revolved so as to traverse them over its surface. In this way it is accurately shaped to suit the conditions of the case, and is as true as a fixed bend could be made. Of course, as soon as the bend requires to be reset it is necessary to adopt the ordinary plan, but the treatment described undoubtedly facilitates subsequent setting.

(122) The plan adopted by Messrs. Platt Bros. and Co. Limited is shown in Figs. 55 and 56, the former being the new, and the latter the old, method. A perspective view of this machine fitted with the new bend is given in Fig. 57. Dealing with Fig. 56 first, the cylinder A is separated from the framing B by the distance shown, this being filled up by the wood packing G. The flexible bend C is fastened to the framing on the outside, and is set by the screws shown. The cylinder in this case is 40 inches wide, and it will be noticed that the arms of the cylinder are level with its edge. In Fig. 55 the cylinder A is recessed so that it projects beyond the arms

sufficiently to permit the bend B to come within the recess. The flexible bend C is attached in the manner shown to B, and is fulcrumed on the pin in its centre. The setting is obtained by means of the screws, as in the previous case. The clothing on the flat is secured at the ends by the clip or plate F, shown separately in side view and plan, and a thin plate E is fastened to the cylinder by which means the ingress of air is quite prevented. There is also a reduction in the widths of the cylinder and machine, in the latter case about 8 inches, so that a machine fed from a lap 45 inches wide occupies only the same space as a machine made on the old principle with a 40 inch lap.

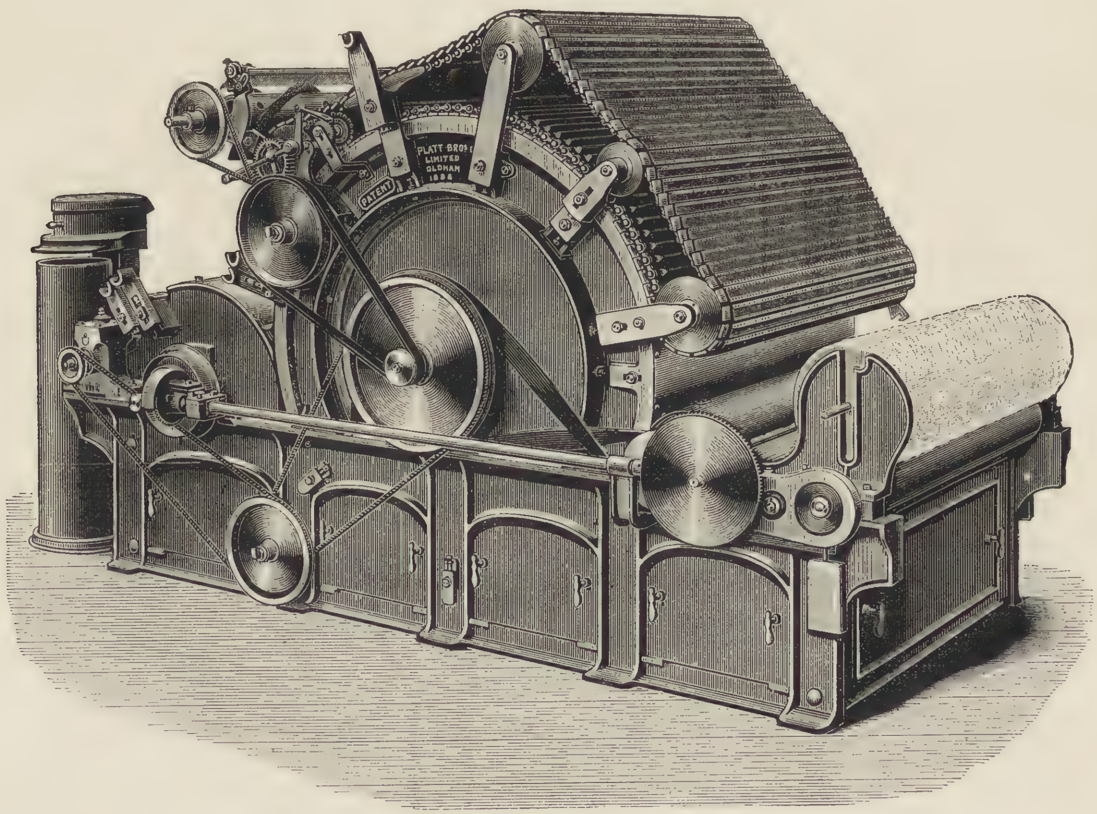
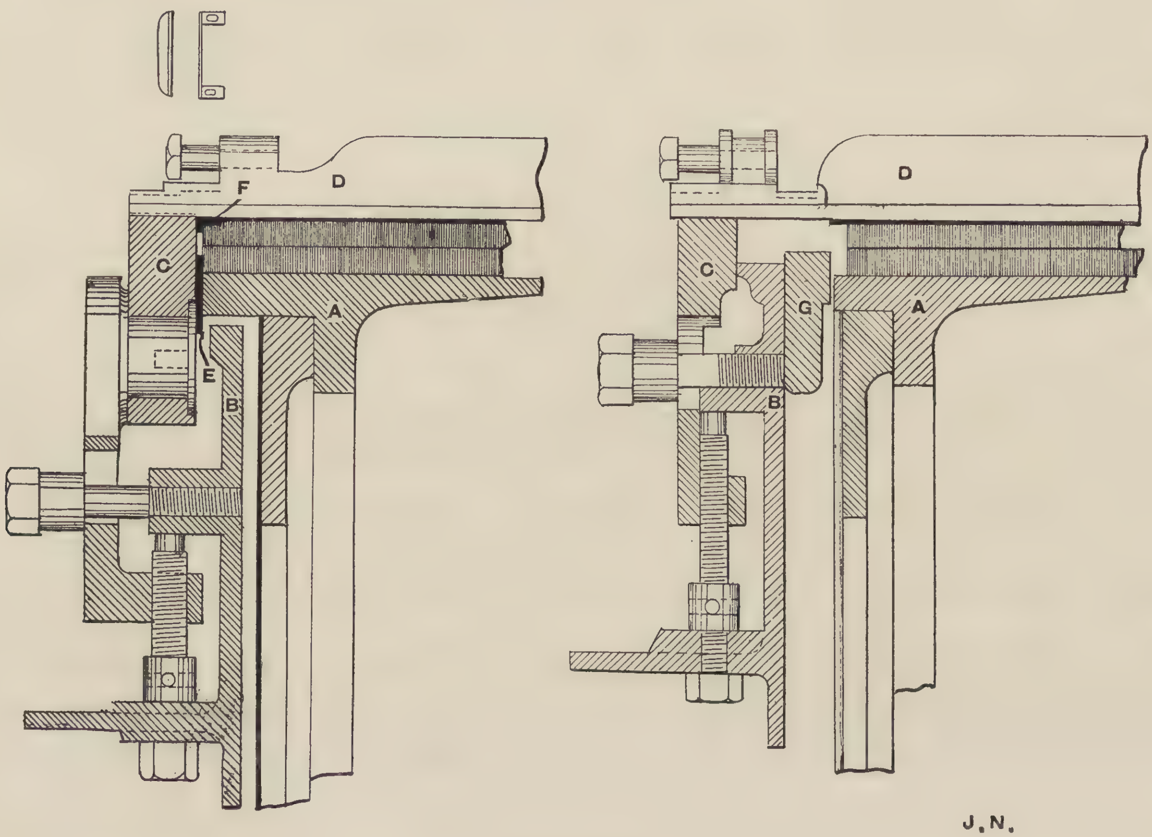


FIG. 57.

(123) Before leaving this point there is one thing to be noticed which is important. A reference to either Fig. 52 or 56 will show that the chain is attached at the end of the flat immediately over the bend, whereas in Figs. 51 and 55 it is further from it. The former method is best, as being less likely to deflect the flat, and is being adapted to the new construction by both the firms named.

(124) The construction of machines with flexible bends, in spite of many objections which are continually being alleged, continues to be large. It is held by some spinners and machinists that the necessity for adjusting the flexible bend manually from three points is faulty, and that it is better to provide mechanism whereby the

setting can be made by positive means and from one point. Several patented arrangements with this view have been made, and illustrations of most of them are given. In most cases a flexible bend—somewhat differently constructed—is used, although it does not always have that name given to it.



Figs. 55 and 56.

(125) In Figs. 58 and 59 the arrangement used by Messrs. Dobson and Barlow—to which the name "Simplex" is given—is illustrated. Fig. 59 is a side elevation of that portion of the machine where the bend is applied. Fixed to the framing Q of the machine are four brackets P, O, M, L, the last three of which are specially curved on their upper edge, while P is shaped to a curve on its inner surface. Fixed in the metal strip K—which is practically the flexible bend—are four pins, each bearing an anti-friction runner, which are kept in contact with the edges of O, M, and L, and with the inner surface of the bracket P respectively. Attached to K, at the opposite end to P, is the crank S, oscillating freely upon a pin fastened in the frame Q. At the end of the bend K, where it is controlled by the bracket P, and, on its inner edge, a toothed rack is formed, with which a small spur pinion engages. The pinion is fixed on the axis of a worm wheel R, rotating on a pin fastened in the framing Q. With the wheel a worm R^1 gears, and this can be rotated by a handle to any desired extent. When the bend K is moved by means of the rack in the direction of the arrow, it is put into tension, and

the anti-friction bowls are drawn down on to the surfaces of the various branches. A glance at the detached sectional view given will show that the various brackets overlap the bend K, which slides between them and the frame Q. The position of the bend is arranged so that between it and the edge of the cylinder there is no open space left.

(126) Having thus described the actual mechanism a few words can be said about Fig. 58, which is a diagrammatic representation of it. The circle A B is that formed by the edge of the bend or plate K when it is at its highest position—that is, when the wire is unworn. The circle D E is that described by the edge of K when it has been drawn down to allow the flats to come nearer the cylinder. The small black dots represent the pins fixed in the bend K. When the latter is moved by the action of the rack and pinion, the end of the crank S follows the path of the circle described by it, moving from B to E during the time the entire depression of the plate is made. The anti-friction bowls in the same period travel in the paths shown, and it will be noticed that each of the curves is differently shaped. If the inner circle F G be supposed to represent that occupied by the edge of K after the crank end has travelled from B to G—a half circle—the curves L M O P would, if prolonged, be of the shape shown. Having obtained them in the manner thus described on paper, they are actually reproduced on the brackets by a milling machine fitted with a copying arrangement. By forming an indicator scale on the worm wheel R the amount of movement of the bend K can be regulated as desired to any degree of accuracy. The proportions of the worm, worm wheel, pinion, and rack, are so arranged that the advance of the wheel $\frac{1}{50}$th inch will raise or lower the bend K $\frac{1}{2000}$th inch. This method is very simple and effective.

(127) The arrangement adopted by Messrs. Howard and Bullough has the central idea of the employment of inclined surfaces, by withdrawing one of which the other can be lowered. It is shown in front elevation in Fig. 60 and in section in Fig. 61. The fixed bend has formed on one side of it a broad flange, which

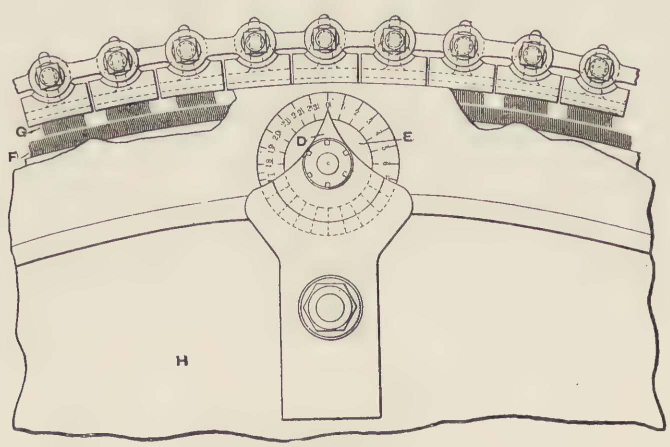
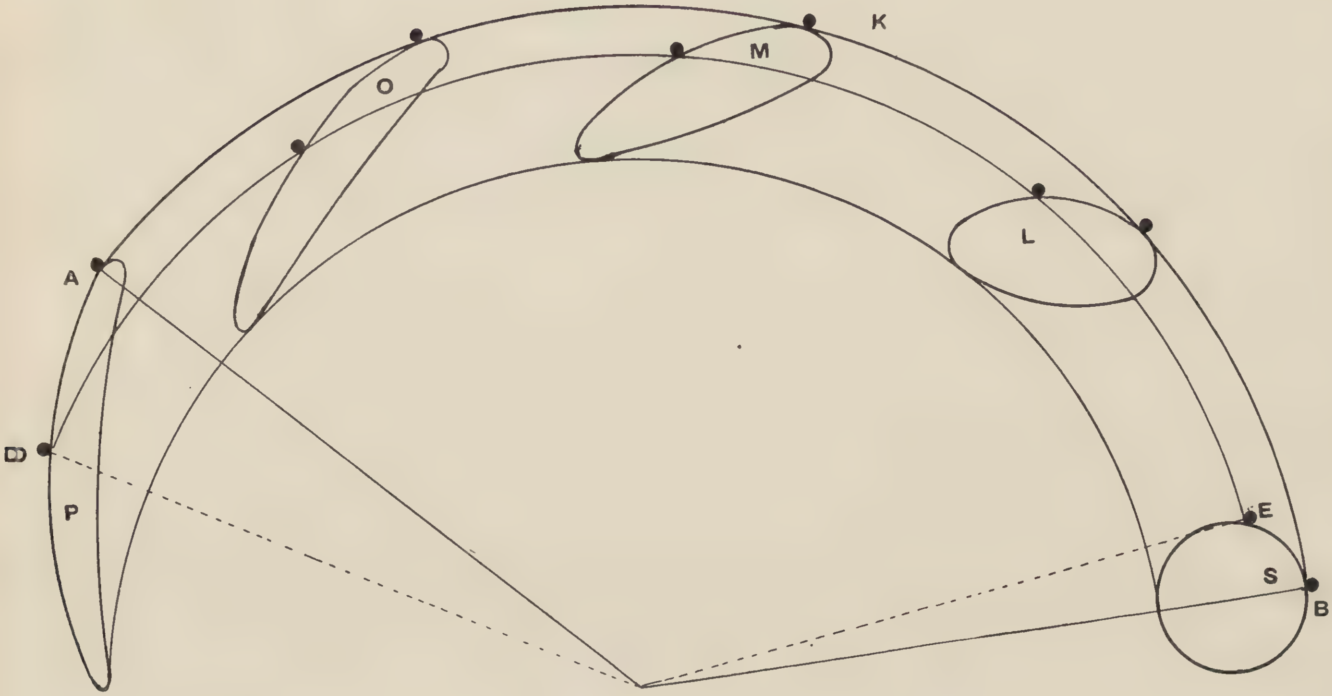
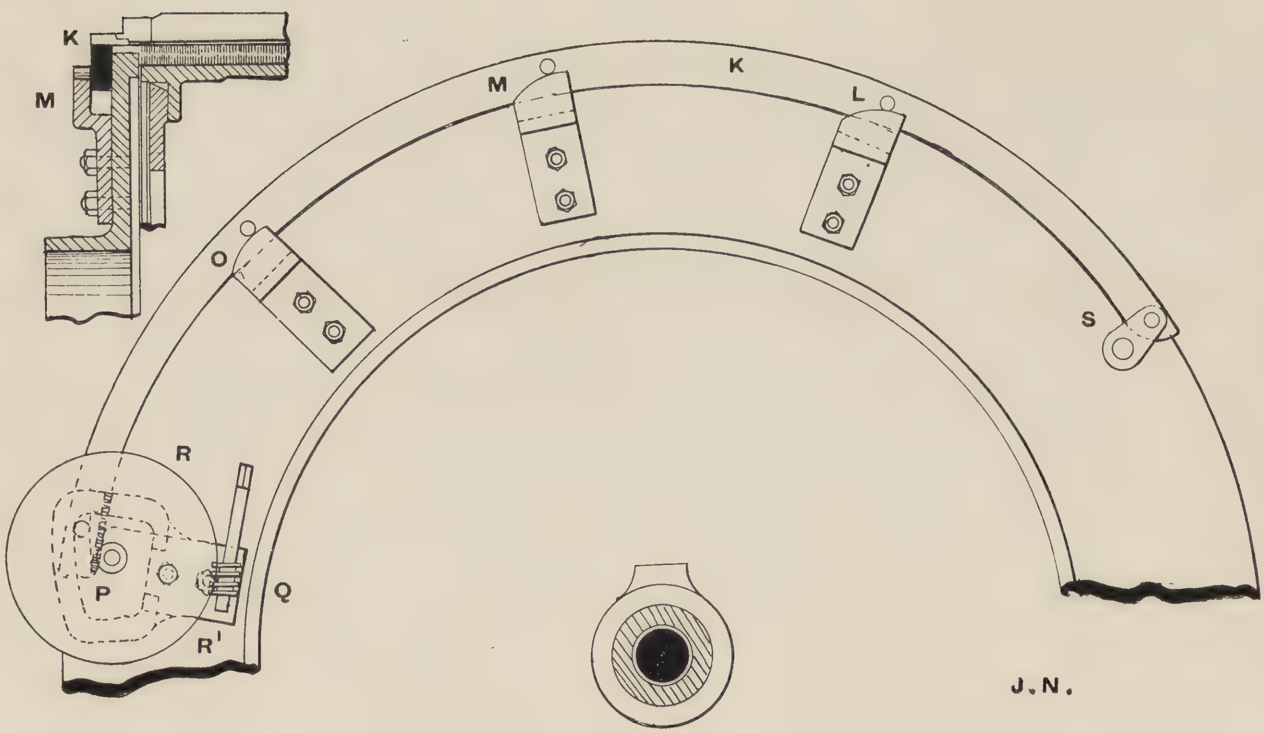


Fig. 60.

is turned to a true circle on its upper edge. Upon this a segment of a ring A is placed, which can be slid in or out by means of the screw B and lock nuts. The back nut is riveted to the index





FIGS. 58 AND 59.

disc E, which is divided into 36 spaces, the front lock nut securing the arrangement after setting. In front of the dial plate E an indicator finger D is fitted, which points out any alteration of the circular dial plate E. Upon the upper surface of the ring A a second ring C of a smaller section is placed. C is accurately turned on its inner side to correspond with the inclination of the upper surface of A, and on its outer edge is horizontal, so as to form a course for the end of the flat. The ring C is pressed down upon A by the weight of the chain of flats as they pass over it. The action of this mechanism is easily understood. By withdrawing the segmental

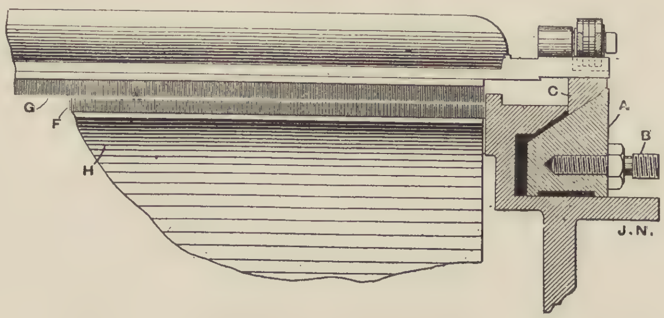


Fig. 61.

ring A, by means of the screw B, the flats are lowered, the degree of their depression being sufficient to preserve the necessary distance between their wire teeth G and those F upon the cylinder H. The adjustment can be made in either direction, and the graduation of the dial E enables it to be finely made. In this case also, as shown in Fig. 55, the gap at the end of the cylinder is closed by bringing the flange of the fixed bend close to the edge of the cylinder.

(128) In Figs. 62 and 63 a plan invented by Mr. Thomas Knowles, of Bolton, and made by Messrs. John Tatham Limited is illustrated. This consists of the employment of a wedge-shaped segmental ring, which

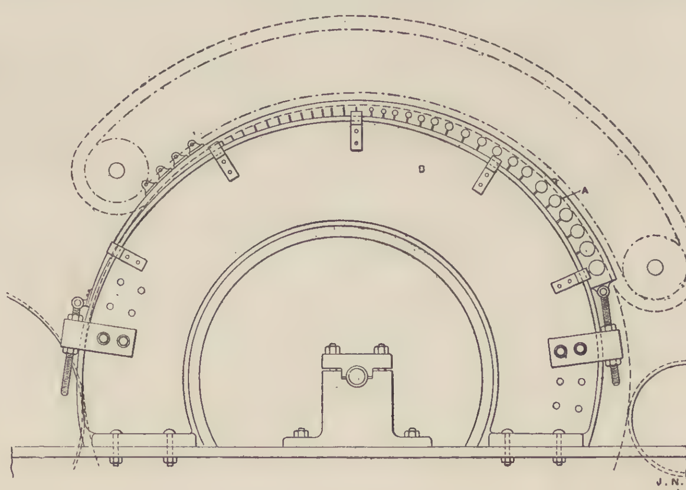


Fig. 62.

rests upon the upper edge of the fixed bend, and can be drawn along it by means of the screw shown. The ring is pierced by a number of holes of decreasing diameter, and a small slit is made through the web

left between the lower part of the hole and the inner surface of the ring. The latter is thus rendered easily flexible, and the mere weight of the flats is sufficient to make it accommodate itself to its supporting surface. The ring is shaped so that the inner edge forms part of a spiral curve, shown diagrammatically in Fig. 63, and with its outer edge levelled so as to bear the flat. In like manner the edge of the fixed bend is shaped to the spiral curve, both of these being obtained by the use of a circular milling machine fitted with the necessary shaping mechanism. The spiral curve to which the two surfaces are formed would,

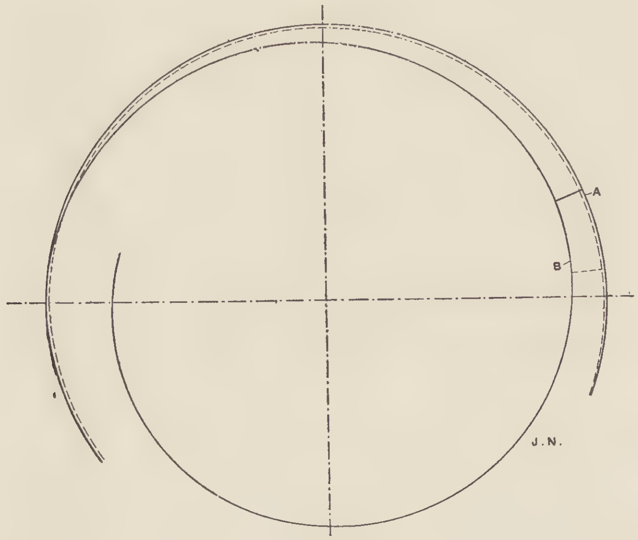


Fig. 63.

if continued far enough, terminate in the centre of the cylinder, so that if it were possible to traverse the ring far enough it would actually cross that point. The action of setting this mechanism is simple. The ring is drawn downwards by the screw, and its outer edge thus moves nearer the centre of the cylinder to an extent corresponding with that of its traverse. Any adjustment desired can thus be given in either direction.

(129) The machine made by Messrs. Ashworth Bros., of which a perspective view was given in Fig. 44, is based upon an entirely different principle. Before passing on to describe it, it is only fair to say that to this firm belongs in great measure the great advance which has been made in the construction of this form of machine. They recognised the importance of accurate mechanical construction, with the result that they produced a machine which could be run at much higher velocities than had hitherto been thought possible. Referring now to Fig. 64, on the top of the fixed bend B, a number (about 15) of thin steel bands E are placed, being held at one end by the stud G and kept in tension by the screw C, thus being firmly drawn into position. The bands are of various thicknesses, from $\frac{1}{30}$th to $\frac{1}{100}$th inch. The end of the flat traverses on the top band F, and any of them can be removed and replaced by a thinner one. Thus the concentricity of

the flat course is preserved, provided that the amount of wear to be taken up corresponds with the difference between the thickness of the band taken out and that replacing it. It may happen that the amount of wear to be provided for is not enough to justify the removal of the band, which, on account of the necessary labour involved, takes some little time. In order to afford a ready means of making the correction, and at the same time avoiding the replacement of the bands, the makers have adopted the bold but ingenious plan of forming the cylinder bearing so as to be adjustable vertically. Referring now to Fig. 64 it will be noticed that the engine bend and the pedestal are cast in one piece, bolted on to the lower frame. The pedestal cap is fastened by means of set screws, but the bottom brass can be lifted by means of the vertical screw shown in dotted lines. This screw is fitted into the pedestal, which is tapped to correspond, and has at its lower end a ring which is divided into 100 parts on its circumference. An indicator finger is fitted so that the ring can set to any of the divisions as desired, and when so set the screw can be

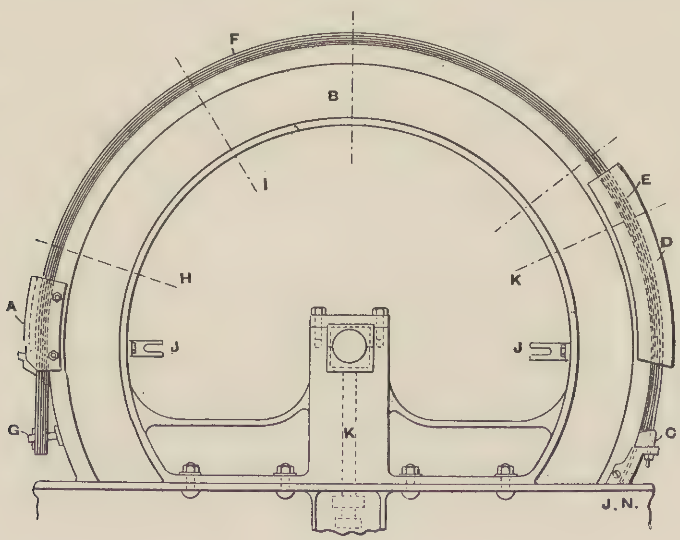


FIG. 64.

locked by a lock nut. By proportioning the pitch of the thread it is clear that any desired lift can be obtained. The pitch adopted being $\frac{1}{10}$th of an inch, a revolution of the screw one division on the ring would mean a vertical movement equal to $\frac{1}{1000}$th of an inch. Now it is quite true that in a sense any vertical movement of the cylinder destroys the concentricity of the flats, but this, after all, is a relative matter. If reference is made to a drawing showing the arc occupied by the flats in various positions, it will be seen that with a total fall of $\frac{3}{8}$ths of an inch the difference between the ends and centres of the arcs described does not amount to a great deal. Therefore if the cylinder was raised by the screw about $\frac{1}{8}$th inch it would not amount to an inaccuracy of any magnitude. But as the thickest band is only $\frac{1}{30}$th of an inch thick it would be most likely that instead of lifting the cylinder anything like $\frac{1}{8}$th inch a band would be taken out and the wear thus compensated for. The raising of the cylinder $\frac{1}{30}$th of an inch would practically mean that the setting of the flats would remain unaltered.

(130) In Fig. 65 is given a side elevation of one side of a carding engine, in which the bend is made in an entirely different manner to any previously described. This is really a revival of a plan which was suggested many years ago by James Smith, of Deanston, but which was dropped on account of certain difficulties in adjustment which are now overcome. The machine as illustrated is made by Mr. Samuel Brooks, and is nearly the latest form put on the market. The pedestal A has a circular flange formed on it about midway of its length, to which a bush C can be bolted by the three bolts M. The bush is placed over the inner boss of the pedestal, and can be set in its proper position, which may be ascertained

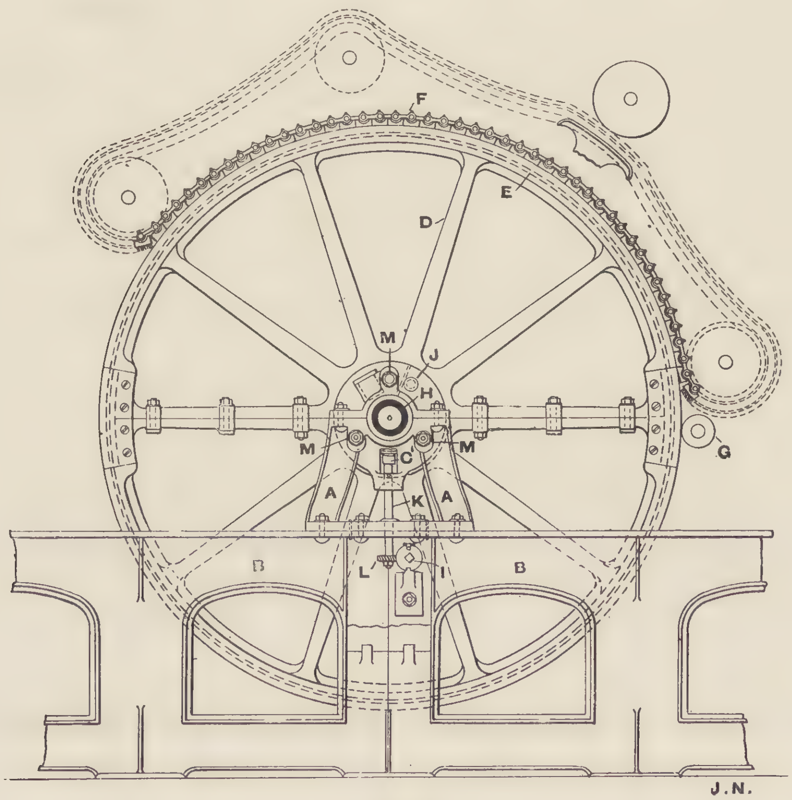
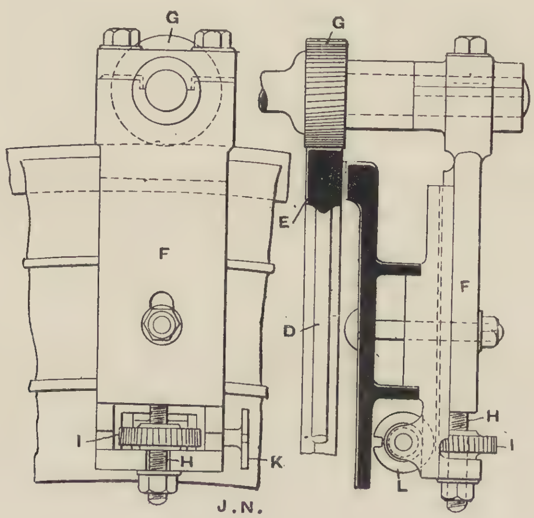


Fig. 65.

at any time by the pin J, passing through a hole in the pedestal flange and one in the bush when the latter is quite concentric with the cylinder, and only then. On this bush a wheel D, with a flat periphery, is fitted and revolves. The periphery E of this wheel sustains the flats F, the traverse of which cause it to rotate at precisely the same circumferential speed as that of the flats. The friction of the flat ends is in this way avoided, which is claimed as one of the important features of the new arrangement. When the machine is new the diameter of the wheel D is of the exact size needed to sustain the flats, and keep the wire points the requisite distance apart, theoretically, $\frac{1}{1000}$th inch. But when the wire has worn and has been re-ground, it

is, of course, necessary to reset the flats. This is effected by means of the milling cutters G, placed as shown, which can be set in by the arrangement shown in side elevation in Fig. 66, and in partial section in Fig. 67. The cutter G is fixed on a shaft borne by the bracket F, which is attached to the bend, and is moved inwards in a radial line by the screw H, the latter being arranged on the micrometer principle. The screw is threaded 25 to the inch, and the worm wheel I has 20 teeth. The rotation of the latter one tooth implies a corresponding movement of the cutter G $\frac{1}{500}$th inch. By subdividing the disc K on the spindle carrying the worm L, as much as desired, the cutters can be moved in or out to a very slight but ascertainable degree. A similar arrangement is fitted to the bush C, by which when unlocked it can be lowered as desired.



Figs. 66 and 67.

(131) In setting, or, rather, in lowering the flats—because that is practically all that can be done by this arrangement—the bush is unlocked and the pin J taken out. It, with the wheel, is then lowered until the wires on the central flat and those on the cylinder can be heard to click. A careful note is taken of the amount which the bush has been lowered, and it is again raised to its central position and locked. Suppose that the amount was $\frac{1}{250}$th inch—a very extreme supposition—then the distance the flats have to be lowered is that distance less $\frac{1}{1000}$th inch, the standard distance between the wire teeth, or $\frac{3}{1000}$th inch. The disc K is therefore revolved $1\frac{1}{2}$ times, which moves the cutters G inward to that extent, and, in consequence, the diameter of the wheel D is reduced, so as to provide a course for the flats of the exact size required. The cutters G are driven by a band from the cylinder shaft, and the wheels C are traversed as usual during the process of reduction. This arrangement is a novel one, but it is clear that, if successfully carried out, it provides a perfectly concentric flat course.

(132) Before proceeding further, and dealing with another form of machine, a few words may be said on the subject of setting the flats. It has been shown that in many cases a delicate indicator and micrometer

screw is fitted, by which it is claimed the most exact settings can be made. There can be no dispute as to the power to do this which is thus provided, the only question is whether the circumstances of the case call for it, and whether in actual work any such accuracy is obtained and maintained. There are four points where adjustment is required in a carding engine. These are between the dish feed plate and licker-in; between the licker-in and cylinder; between the cylinder and flats or rollers; and between the doffer and cylinder. Messrs. Platt supply three guages, respectively ·013, ·011, ·007 of an inch thick. The finest of these it will be seen is $\frac{7}{1000}$ths of an inch thick, so that in this case at least the theory as to setting to $\frac{1}{1000}$th is disregarded. In adjusting the flats, by far the commonest plan is to do so during the time the mill is standing, when everything is quiet. The bend is then dropped until the guage which it is intended to use can be pushed between the two sets of teeth. If it is afterwards desired to get very fine setting, the bend is lowered until the slow revolution of the cylinder produces a "click," which shows that the teeth of the cylinder and flats are in contact. A little elevation is given to the bend so as to leave a space between the teeth. A skilful setter can tell at any time by the "touch" of the teeth if they are too closely set, but the vibration existing during working hours may disturb his observation. When an indicator is used the practice is to establish the clicking point, and then turn back the screw until the flats are raised the desired distance.

(133) It is questionable whether it is possible to maintain so accurate a setting during actual work over a long period after wear has begun. It is hardly likely that many machines continue to work with this close setting. The practice is rather the other way. Wider spaces than ·011 are common, and it is unreasonable to expect anything else. The function of the wires on the cylinder being to seize by means of their points the fibres of cotton and bring them under the influence of the flats, it is obvious that the question of efficient carding turns very largely upon the charge of cotton in the wire. If light carding is taking place—that is, if little cotton is passing over the cylinder during a fixed time—the delicate setting is both possible and desirable, as it would result in the cotton fibres being thoroughly combed from end to end. But if the cotton is fed rapidly, so that the cylinder becomes highly charged and its surface covered with a comparatively thick fleece, a too close setting would result in considerable damage to the fibre. As the prevailing practice is generally based upon commercial considerations, the last is the more usual condition existing, and extremely close setting is in this case both impracticable and undesirable.

(134) Even if this extra fine setting named were adopted there is nothing to show that it cannot be attained with the flexible bend. True, the setting of the latter involves a little more labour, but is it quite demonstrated that it is not necessary labour? The construction of flexible bends is now such, as has been shown, that their flexure, $\frac{3}{8}$ths of an inch, is made with absolute ease and accuracy by means of the setting screws. There is an old adage that "the proof of the pudding is in the eating," and no candid person will contend that carding engines made with flexible bends of the Leigh type produce either worse slivers or make more waste than others. On the other hand, it is only fair to say that the converse of this proposition holds true, and that good slivers are obtained from machines made with indicators and special setting appliances without more waste being made than in the

case of flexible bend machines. It is, however, more than probable that the system of setting by the ear is adopted in every case of successful carding.

(135) A further consideration in connection with this question is the problem of adjustment after the cylinder bearing has worn so as to alter the position of the centre of the cylinder. In this case the cylinder can be followed by the flexible bend and concentricity re-established, whereas, in the case of other arrangements which are based upon an unyielding surface attached to the framing, no such practice is possible. In this case it is necessary to provide a means by which the cylinder centre can be restored to its original position. The methods of doing this will be touched upon at a later stage.

(136) Before leaving the question of setting, it may be stated that the distance between the licker-in and the dish feed-plate is regulated according to the quality of cotton treated. Ordinarily the thickest guage ·013 is used by Messrs. Platt, but if the cotton is deficient in strength the distance is increased by the thickness of the medium guage, or in all is made ·024 inch. The licker-in is set by the medium guage ·011, which is slipped easily between the licker-in teeth and those on the cylinder. The space left between the doffer and cylinder teeth is smaller, the finest guage ·007 being employed in this case.

(137) In paragraph 132 it was stated that setting was mainly conducted by means of a guage and by ear. It is often desirable to ascertain during work how the flats and cylinders are set relatively, and it is highly desirable to do this without disturbing the flexible bend. Up to quite recently this could only be done by guaging at each end in the ordinary way, and in the centre by the ear. Messrs. Platt Brothers and Company have, however, devised a method by which the setting of the flats can be instantaneously ascertained, and power is thus given to a spinner or overlooker to check the setting. In the flexible bend, at four points, narrow oblong slots are formed by casting, and are made of such a width that the carder's guage can be easily slipped between the cylinder and flat teeth, whatever may be the condition of the wire. The slots are, during work, stopped by plugs, which can be instantaneously withdrawn. The makers state that they have made careful tests to ascertain whether the presence of the slots affects the deflection of the bend, but do not find any ill effects. This is an extremely simple but very valuable improvement, and affords an opportunity of checking the setting, which cannot but be beneficial.

(138) The third form of carding engine is that known as the "Wellman," or "Self Stripper." It is extensively employed on the Continent, and in the United States. It is the direct descendant of Paul's machine, inasmuch as it is based upon the principle of the employment of fixed flats superimposed upon the cylinder. In the early days of carding machines the flats surrounded a certain portion of the cylinder, and when they became charged with fly were lifted and stripped by hand. This practice was found to be very inconvenient, and a method of raising the flats automatically was therefore welcomed. For the finer counts of yarn cards on this principle were extensively employed in England, but the improvement of the revolving flat card has displaced it, and in this country at least it may be looked upon as an extinct type. The mechanism of the Wellman is ingenious, but for the reasons stated only a brief description of it will be given. Students who are interested in the subject can study it in the works of Mr. Evan Leigh in English, Mr. Neiss in German, or in one or two French books.

(139) The self-stripping card as made by Messrs. Dobson and Barlow, is shown in side view in Fig. 68. The flats A cover the surface of the cylinder for about the same extent as in the revolving flat card. They are, however, stationary, and rest upon brackets B, each of which is capable of separate and delicate adjustment. On the cylinder shaft C an arm or lever D is placed, which is free to oscillate as required, its position being regulated by a pinion engaging with the rack E. The motion is driven from a grooved pulley, fixed on the cylinder shaft, which gives movement to a wheel behind the catch plate or wheel F. A sliding jaw traverses in the long slot at the top of the arm D, and is raised by a cam fixed on the spindle of the wheel F. When this upward movement of the jaw takes place the flat is lifted and held tightly between it and a fixed jaw formed on the arm D. While in this position the lever G, hinged at

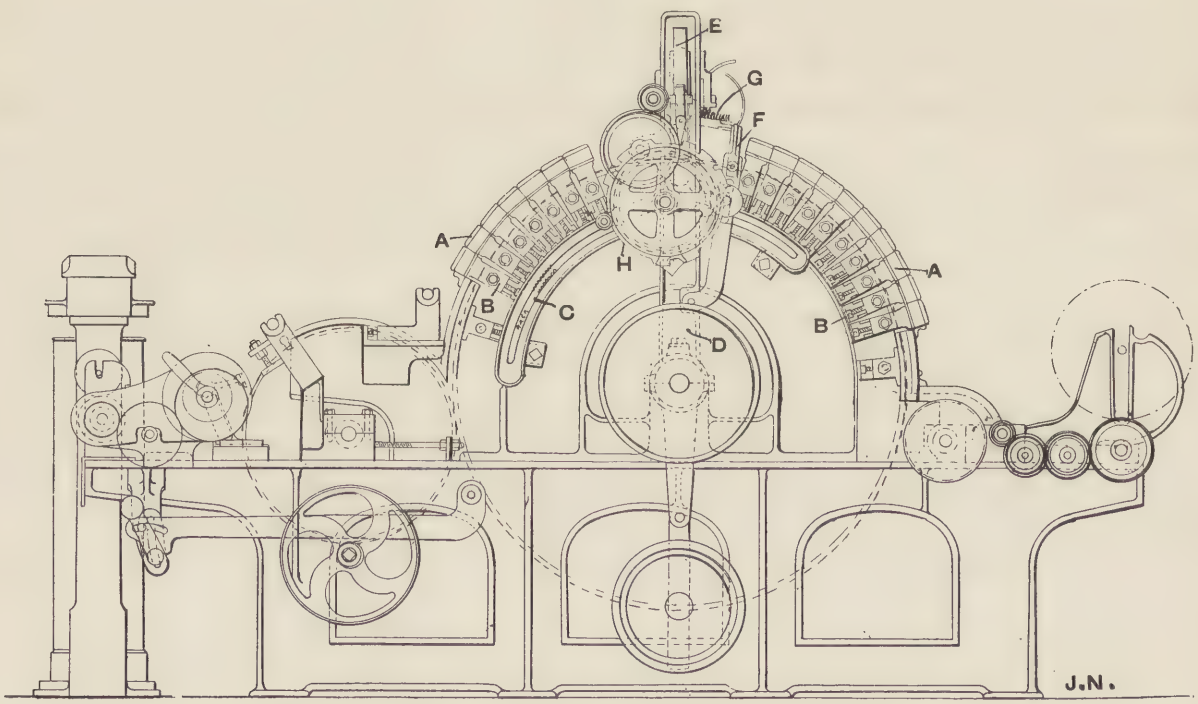


Fig. 68.

its lower end to D, is drawn inwards, and as it carries a wire stripping brush H it causes the teeth of the latter to pass through those of the raised flat, and thus remove the dirt and short fly. Immediately one passage is made the brush returns, and the flat is at once lowered into its position above the cylinder. By an extremely ingenious arrangement of mechanism the flats are not stripped consecutively, but are arranged to be stripped oftener near the licker-in than at the doffer end. The reason of this is obvious. By virtue of their position the earlier in the series of flats retain more dirt, and therefore require stripping oftener.

(140) From the mechanical point of view, the Wellman card and its predecesors will repay careful study, but as stated in paragraph 138, it has ceased to be used in England, and does not, therefore, come under the

head of "modern" machinery. Yet there are principles involved in the Wellman which are of high merit and importance, and a system of carding is possible on this machine which is not possible on any other. To begin with, the distance of the flats from the cylinder may be varied at will, and instead of each flat being concentric with the latter, the circle described by the series may have another and distinct centre. That is to say, the flat at the feed end could be $\frac{1}{8}$th inch away from the cylinder, while the one at the doffer end approached within $\frac{1}{500}$th inch, all the intermediate ones being set proportionately. Again, the pitch of the wire teeth upon the various flats can widely vary. Those at the feed end may be, and often are, much coarser than those at the delivery end, a proportionate gradation of pitch occurring throughout the whole series. It will be at once seen that the conditions prevailing in a revolving flat machine are entirely contrary to this practice. In that machine the setting of all the flats is devised so as to make them equidistant from the cylinder centre, and every flat must of necessity be covered with wire clothing of the same counts.

(141) The effect of the peculiar setting referred to is, that, as the cotton is carried round by the cylinder, the fibres are gradually straightened by a series of combs which are at once nearer to the cylinder surface and finer in pitch, as the doffer is approached. Supposing, for instance, the pitch of the teeth on the first flat was $\frac{1}{8}$th inch and their distance from those on the cylinder also the same, it would follow that the fibres flung up by the rotation of the cylinder would be at most only lightly treated. If, however, the pitch of the teeth and their setting became gradually finer, until the latter was reduced to $\frac{1}{500}$th inch, it is easy to understand that the fibres would be, by a series of grades or steps, carded or combed. This treatment, on account of its gradual nature, results in the fibres being drawn out very straight, and is, when properly conducted, the nearest approach to combing which has been attained on a continuous carding machine. For the longer stapled cottons the use of a machine by which settings of gradually increasing fineness are obtained is especially suitable, and it was for these that the machine was mostly employed. Of course, the figures given above are merely hypothetical, and are used only to illustrate the point at issue.

(142) The defect of the Wellman machine in modern eyes is principally its slow velocity. The great weights which are now obtained from revolving flat cards cannot, or at any rate have not, been obtained from the self-stripper, and, in consequence, the latter has become discredited. But it must not be forgotten that the former machine has had an amount of mechanical skill lavished upon it which has been absent from the latter. This does not mean that the Wellman has not been well made, but it has not been so well constructed as the revolving flat type has during recent years. It is quite within the bounds of possibility that the self-stripper may have a revival, when its undoubted capability for good work may be combined with great productive power. It is often combined with a roller machine and used as a finisher carding engine, and is in other cases fitted with two or three rollers before the flats are reached.

(143) Reference was made in paragraph 105 to the use of a dish-feed. In Fig. 69 illustrations are given of this part of the mechanism, as made by Messrs. Dobson and Barlow, this being a reproduction of an illustration contained in a pamphlet on "Carding," by Mr. B. A. Dobson. It will be seen that the feed-roller A revolves in the curved portion of the plate C, and that the nose of the latter is specially shaped to suit various

classes of cotton. The principle involved here is precisely that referred to in paragraph 94 in dealing with the scutcher feed. The shorter the staple the more acute the surface from which it is struck can be without damaging the fibre. While a long fibre will permit of bending round a roller or lever end of large size, the shorter stapled varieties will simply be dragged downwards and crushed with precisely the same treatment. A close examination of the three views marked K, G, and R will illustrate this point, these being respectively for Surat, American, and Egyptian cotton. The adoption of the dish-feed is one of the most important of the minor improvements made in the carding engine, and leads to the straightening out of the lap end, owing to the exactitude of the rate of feed which can be attained. For the full success of this appliance it must be used in conjunction with the saw tooth on the licker-in, a description of which is given in the next chapter. This is a description of tooth which does not become charged or choked with dirt, nor does it require grinding, so that it is always in condition to deal effectually with the cotton. The action of this class of tooth is very graphically shown in Figs. 70 and 71, two reproductions of photographs in Mr. Dobson's paper above referred to, of a lap end before and after the licker-in has acted upon it. They very clearly demonstrate the enormous effect produced by the licker-in teeth, and show how effectually all dirt and motes are removed.

(144) Again referring to Fig. 69, it will be seen that below the dish C two blades or "mote knives" are placed, which can be readily adjusted so as to present a sharp edge to the cotton as it is flung down by the licker-in, and so scrape off the "motes" from its surface. The object of these knives is similar to that of the leaf extractor used in a scutcher, and described in paragraph 77. Beneath the licker-in and beyond the knives a casing E is placed. These are usually made of tinned iron, and form a sort of grid through the interstices of which the droppings can fall. From their position they are known as "under casings." The exact setting of these is a matter of high importance during working, and should be ascertained by observation when dealing with different classes of cotton. It has been found that the use of under casings with the licker-in has been attended with considerable economy. They are also used beneath the cylinder, and should be as carefully set as is the case with those under the licker-in. In determining the distance, regard should be had to the quality of cotton used and its length of staple, as, if the fibres actually strike the bars of the grid, they may adhere to them and partially choke the latter. On the other hand it is found that too wide a setting is followed by increased waste. It is both possible and advisable to find the golden mean by observation. Messrs. Platt Brothers and Co., Limited, have a special way of forming the undercasings, the bars of which are secured to turned wrought iron segmental rings, the position of which can be regulated from outside the machine by special setting screws. They also attach the licker-in casing and mote knives to the cylinder under casing, so that they are all set in combination, and an alteration of the position of the licker-in leads to a readjustment of all its attachments. The three guages mentioned in paragraph 132 are combined, and the casings set sufficiently far from the cylinder to permit of the introduction of the three guages. That is to say, the space left is ·031 of an inch, which is found to be generally ample, but this is subject to the remarks previously made.

(145) In addition to the necessity for under casings, covers are required for the licker-in, cylinder, and doffer. As the circles described by the teeth on these three parts approach each other, as shown in

Fig. 46, it is desirable that the covers used should go as near to the point of approach as possible. If any space is left the fly and dirt speedily fills it, and from time to time drops upon the doffer, causing a thick place in the sliver. The arrangement used by Messrs. Dobson and Barlow is shown in Fig. 72, and it will be seen that the cover goes close down into the space left between the cylinder and doffer, and effectually prevents any accumulation of dirt. The cover is in three parts, and is hinged so as to permit of the surface of either cylinder H cr doffer F being stripped or ground as desired. Setting

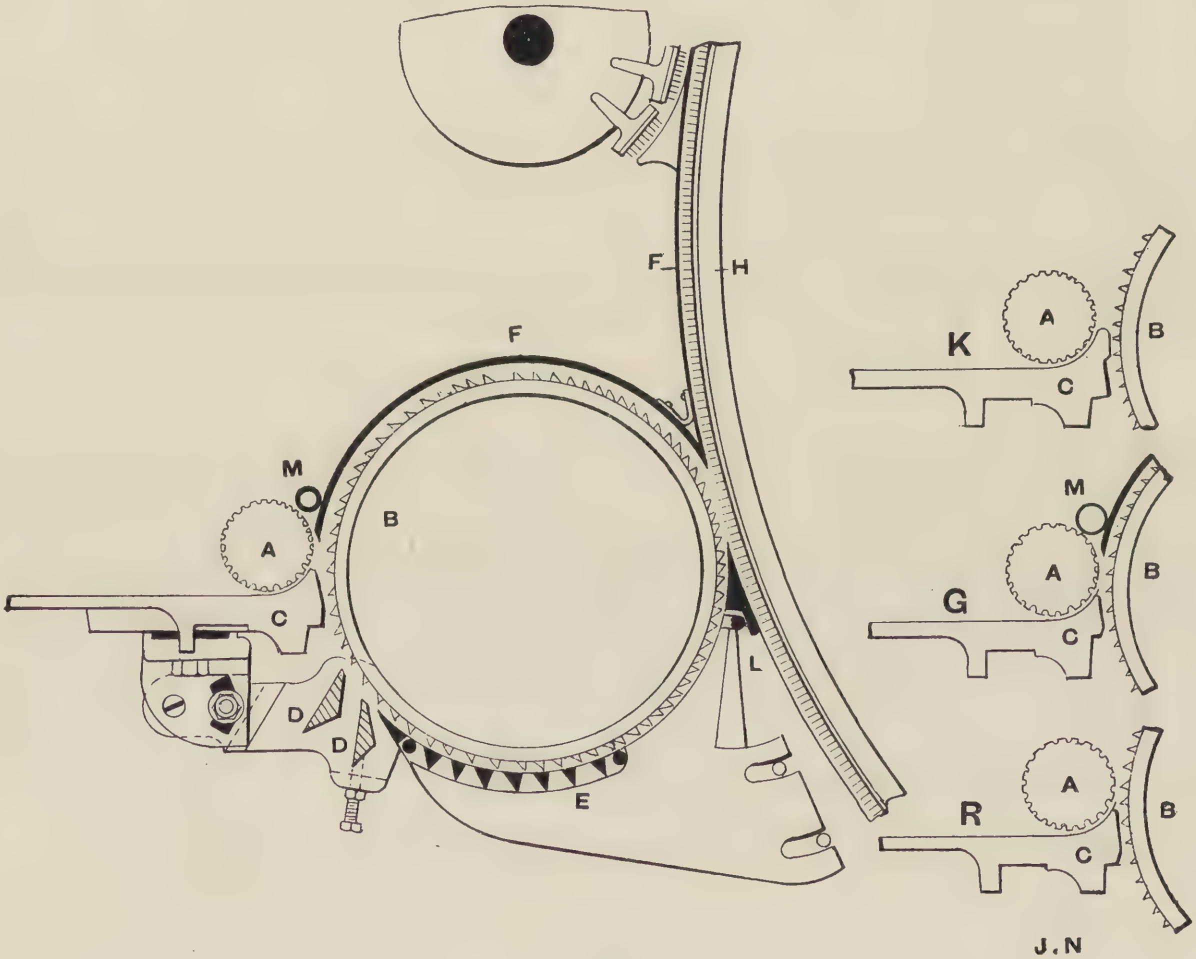


Fig. 69.

arrangements are provided, by which the cover can be maintained in an accurate position during the whole period of work, although it may be necessary to set the doffer in towards the cylinder. The shape of the centre portion is specially designed to permit it to receive the strippings from the flats. Again referring to Fig. 69, it will be seen that similar arrangements are made for the licker-in and flats, the space between the flats and the cylinder wire being filled as shown, as is also the space between the licker-in and cylinder. The cover F over the cylinder and licker-in can be set up as desired, as can also the filling piece L below.

All the covers are arranged to fit closely to the bend at the edges, so that there cannot be any blowing out at the side of the cylinder.

(146) The driving of the cylinder is obtained from the line shaft by means of a fast pulley fixed on the cylinder shaft, a loose pulley adjoining it to facilitate stoppage. The licker-in is usually driven from the cylinder by a crossed strap, and the doffer from the licker-in by a similar strap, which passes over a pulley mounted on a stud fixed in a lever. The pulley has a pinion on its boss, which engages with the doffer wheel U, and so drives it. The pinion, or "barrow-wheel," can thus be easily thrown out of gear, as desired. The feed-roller is driven

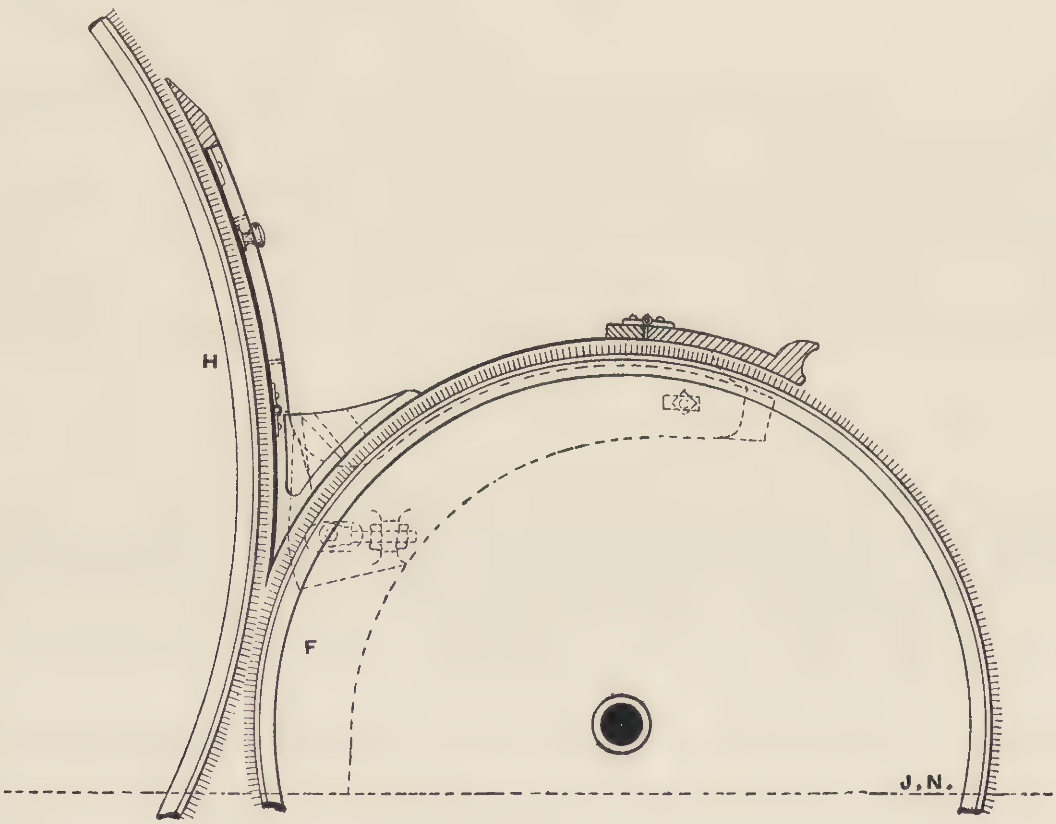


Fig. 72.

by a side shaft from the doffer shaft, placed on the other side of the machine to the main driving and the doffer comb by a cord passing over a grooved pulley on the cylinder shaft. The calender rollers are driven from the doffer, and the coiler shaft from the spindle of the calender roller.

(147) The pedestal is constructed with an extra long bearing, the shaft being $3\frac{1}{2}$ inches diameter and the bearing 7 inches long. The bush lining the pedestal is usually made of phosphor bronze, or some equally good material, in order to resist wear. It was pointed out in paragraph 119 that it is essential that the position of the centre of the cylinder shall be continually maintained, and it is therefore desirable to guard against

its movement. If it is considered, it will be understood that the centrifugal action set up by the rotation of so heavy a body as a carding engine cylinder will cause it to endeavour to roll forward, and thus induce wear in the front of the cylinder bearing. This is aided by the pull of the strap, which is usually towards the front. The provision of some ready means by which the wear can be taken up and the position of the cylinder centre restored, is, therefore, of great service. It is not practicable to employ the conical bearings often used in other classes of machines, as the wear not being equal, a tightening of the bearing would not take it up.

(148) Messrs. Howard and Bullough adopt a plan by which the pedestal is fitted upon two wedges, or inclined metallic surfaces, placed one above the other. By setting one or both of these wedges in either direction, the pedestal is so adjusted that the cylinder centre can be moved either laterally, vertically, or angularly, as is required. Another plan, adopted by Messrs. Ashworth Bros., consists of the formation on the pedestal of three projections, or claws. The inner surface of these is bored concentrically with the pedestal bearing, so that when the cylinder is in its true position, a cylindrical template, bored to correspond with the diameter of the shaft, and turned on its outer surface the same size as that to which the projections are bored, can be easily pushed up to the face of the pedestal. Unless this can be done the cylinder is not concentric, and the adjustment of the bearing must be made accordingly. Messrs. Dobson and Barlow employ the device shown in Fig. 73, which consists of two eccentric bushes, X Y, surrounding the bush in which the shaft Z revolves. The eccentricity of each of the bushes is equal, and thus by moving one or both the position of the centre of the cylinder can be adjusted at will, either laterally, vertically, or angularly. To facilitate the adjustment, two screwed rods, U V, are attached respectively to lugs formed on the bushes X Y, and pass through brackets formed on the pedestal. By means of nuts placed at each side of the brackets the adjustment of the position of the eccentric bushes can be made at will.

(149) In order to diminish the evil effects of the pull of the strap, as mentioned in paragraph 119, the plan shown in Fig. 74 has been adopted by Messrs. Ashworth Bros. Instead of keying the fast pulley on the shaft, it revolves on a hollow boss C, which has a flange or plate attached to the pedestal F. The pull of the strap on the fast pulley A is therefore taken by the bush or hollow boss C, and not by the shaft. Fixed on the shaft is a coupler D, which is formed with two arms engaging with corresponding recesses in the centre of the boss of the pulley A, something similar to the ordinary driver used in turning. By these means the shaft is rotated without there being any pull upon it, and one fruitful source of forward wear is thus removed.

(150) The three points which it is necessary to bear in mind in regard to carding were indicated at the opening of this chapter. These were the cleansing, parallelisation, and attenuation of the lap, and a few words may be said about each in that order. The velocity with which the teeth of the licker-in strike the end of the lap causes the fibres to be effectually loosened, and shakes a good many of the motes out of the cotton. Others are left on the surface of the fibres held by the licker-in wire, and are removed by the mote-knives as described, while some enter the spaces of the licker-in covering, from which they are easily thrown. On passing to the cylinder, the short fibres are largely thrown off as fly, or when they are subjected to the combing

action of the wire teeth on the rollers or flats they are removed, and become fixed in the spaces in the covering. The "neps" are in a similar way taken out of the fleece, and from this cause periodical stripping is desirable of both rollers and flats. By reason of the centrifugal action of the cylinder many short and nepped fibres are driven into the roller or flat wire, but a certain proportion also remain in the cylinder wire, which also requires stripping periodically.

(151) It is somewhat difficult to define the exact action of the wire points by which the crossed and tangled fibres in the lap are laid in approximately parallel order. There is little doubt, however, that the speed of the cylinder plays an important part. The fibres are by the action of centrifugal force thrown out, so that, while held at one end by the cylinder wires, they are rapidly drawn through the wires on the rollers or flats. If the grip of the fibre is slight, as in the case of a short fibre, it will be removed, but, if it is sufficient to hold, it follows that the fibre would be combed by the superimposed wire teeth. In this way the thickness of the fleece on the cylinder plays an important part in determining the amount of parallelisation the fibre receives. If this is thin, each fibre, in all probability, receives its due treatment, while, if it is thick, the fibres are dragged—so to speak—through the wire teeth above, and would be likely to be injured, besides which their arrangement is more difficult. For this reason, the lighter the carding—that is, the less the weight of cotton passing at a given time—the better, provided that this is not pushed so far as to be uneconomical. It has been pointed out that the setting of the flats in the self-stripper lends itself peculiarly to effective combing, as the pitch of the wire teeth and the distance between them and the cylinder teeth can be gradually made finer. In the case of the roller card the fibres are lifted off the cylinder, and, if well held, would be drawn straight in the process. In their transfer by the clearer to the cylinder the fibres are further dealt with, but it is problematical whether the alternate raising and return of the fibres from and to the cylinder, results in a parallel order being obtained equal to that by other machines. A good result arises from the use of a roller card as a breaker, and a self-stripper as a finisher card, and this arrangement is often adopted.

(152) The attenuation of the lap is one of the most important functions of the carding engine, because it is the first stage in the formation of a thread, by reason of the easy condensation or collection of the thin film into a strand. Assuming that the feed roller is $2\frac{1}{2}$ inches in diameter and makes one revolution per minute, it will deliver 7·854 inches of lap. The licker-in being 8 inches in diameter, and revolving at a speed of 400 per minute, is capable of delivering 10053·12 inches. As it cannot get this length of lap, it follows that in its revolution the teeth remove a small portion of the cotton continuously, and thus produce a layer or fleece, which is increased in length and diminished in thickness. The ratio of this increase is that just given, being equal to 1,280 : 1. When the cotton is transferred to the cylinder a further reduction takes place. The cylinder, being 50 inches in diameter and revolving, say, 150 times per minute, is capable of delivering 23,562 inches of cotton, or 2·34 times as much as the licker-in. Thus, up to this stage, the lap is elongated 3,000 times, as compared to its thickness when passing the feed roller. If the lap is $\frac{1}{40}$ inch thick the fleece on the cylinder, if spread out, will only be $\frac{1}{120000}$ inch thick. It will be easily seen by a

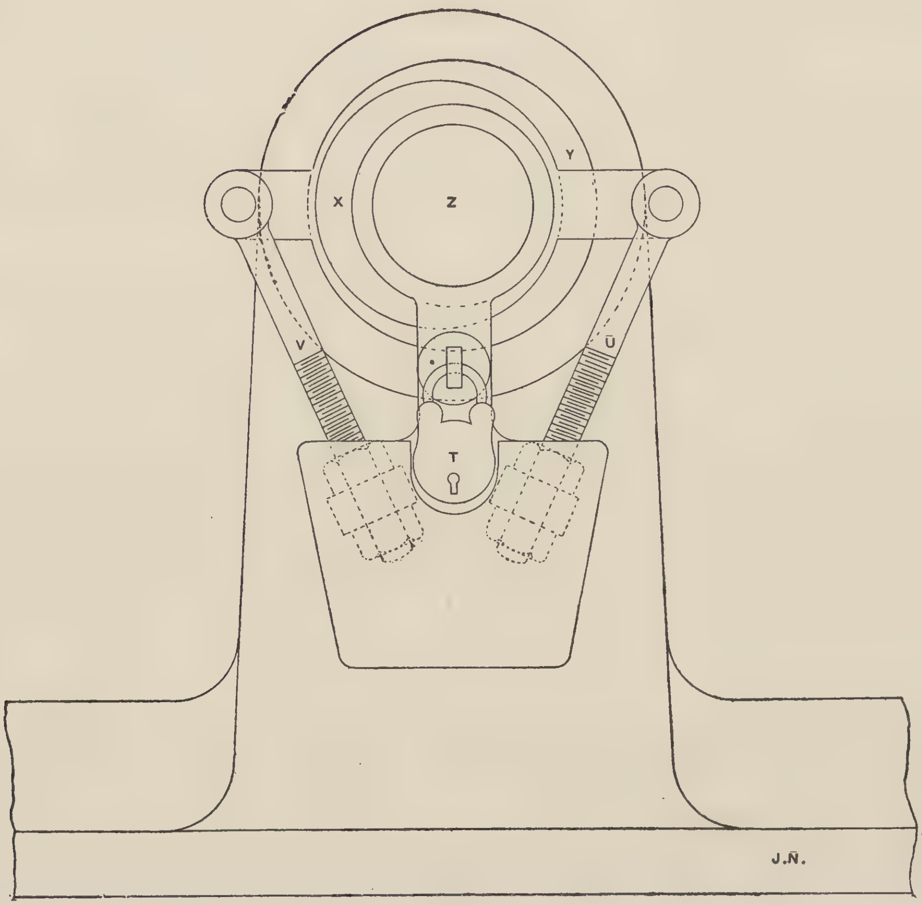


Fig. 73.

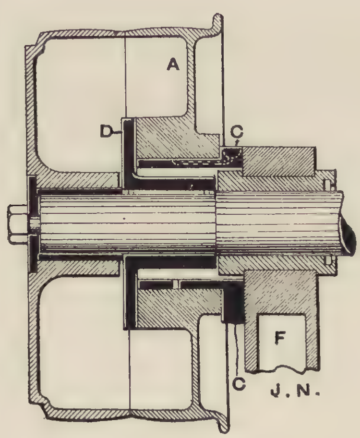


Fig. 74.

reference to the sizes of the cotton fibres that this is much thinner than the smallest diameter of individual fibres, and it follows, therefore, that if there was only this amount of cotton on the cylinder there would be many bare places. As the work of carding proceeds the cylinder becomes charged with cotton, but is never so full that the fibres cannot be carded thoroughly and individually, unless the rate of feed is excessive or largely increased. As the fleece is deposited on the doffer the reverse process occurs, as the doffer, being 24 inches diameter and revolving only 12 times per minute, would only deliver 904·78 inches, or $\frac{1}{26}$th of that of the cylinder. Thus, the sliver, when collected, would be about $\frac{1}{115}$th of the thickness of the lap. These figures are, of course, only approximations. As was previously shown in paragraph 112, the rollers and clearers in a roller card revolve at a much slower speed than the cylinder. The cotton is therefore subjected to a series of condensations and attenuations as it passes round the machine.

(153) An enlarged view of the sliver as it leaves the doffer is given in Fig. 75, and shows that the fibres, although not in parallel order, are arranged so that a slight additional pull is sufficient to straighten them. This the sliver receives partially between the calender rollers and the coiler, but it is in the drawing frame that the greatest effect is obtained. The draught there exercised speedily causes parallel order to be attained in the sliver, which is in good condition for this action. The draught in a carding engine takes place between the feed rollers and licker-in, between the licker-in and cylinder, and between the calender rollers and coiler, the total draught being reckoned between the feed roller and coiler. The question as to the speed of the doffer turns upon the amount of condensation required and the weight it is desired to get through the machine. There is a distinct relation between the speed of the cylinder and that of the doffer, but it has never yet been practically fixed, and carders vary in their speeds considerably.

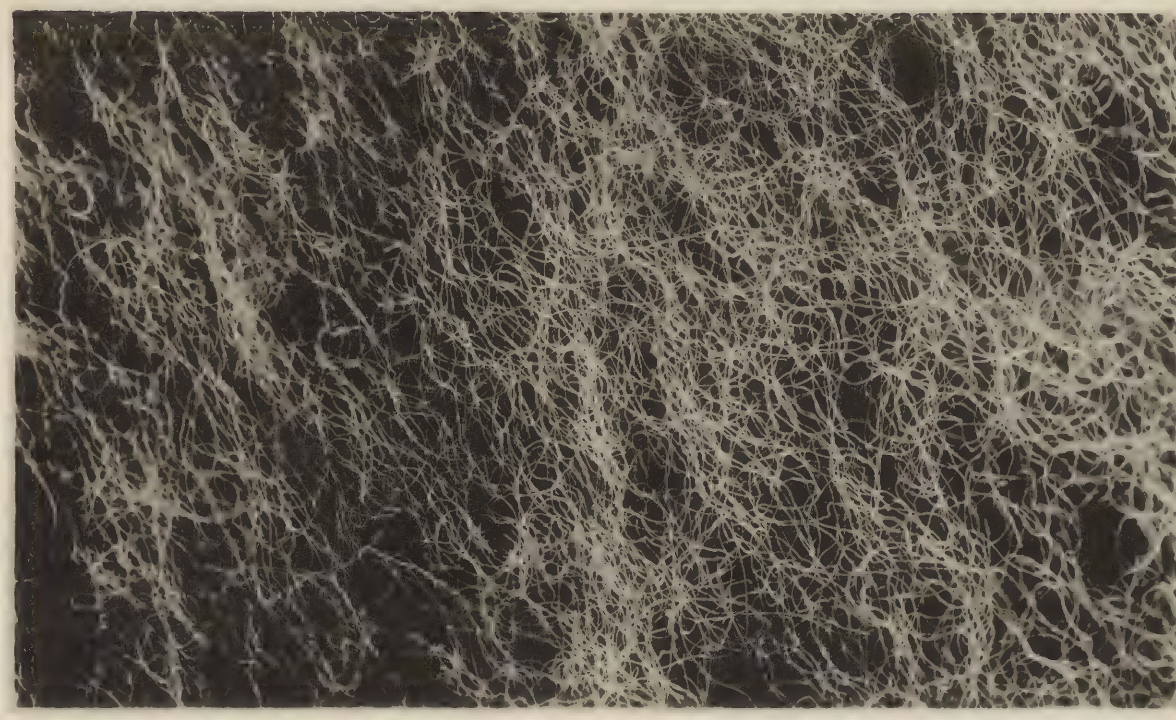


FIG. 75

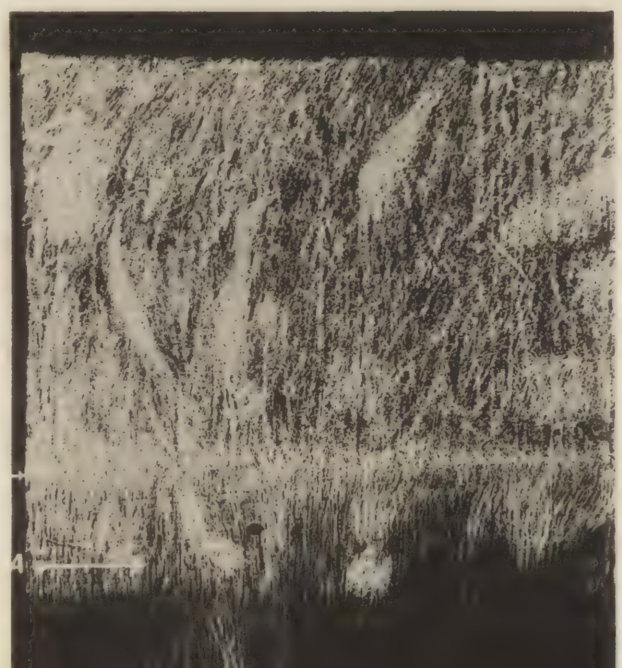


FIG. 70.

FIG. 71

CHAPTER VII.

CARD CLOTHING, GRINDING, AND STRIPPING.

(154) As was shown in the preceding chapter, the cylinder, doffer rollers, &c., of carding engines are covered with a wire clothing, the proper construction of which is of high importance. It forms a sort of wire brush, in which the points are fixed in a special matrix, or "foundation," as it is called. Formerly it was the universal practice to make the foundation of leather, but various considerations have led to its abandonment, except in the case of woollen cards where an oily or greasy material requires dealing with. In lieu of leather three specially prepared materials are now employed, one being what is called a cotton-wool-cotton, another cotton, and the third a natural rubber foundation. The first of these consists of two thicknesses of cotton cloth specially woven with a wool fabric cemented between them. The rubber foundation consists of a thin sheet of natural indiarubber imposed upon and securely cemented to a back of cotton and wool. Great care is taken that the india-rubber shall be pure, and in some cases the manufacturers of card clothing also produce their rubber sheets. The object aimed at in each case is to obtain a foundation which shall be strong enough to hold the wires securely, and at the same time be possessed of some elasticity, so as to aid the wires to recover their position when bent during work.

(155) It was at one time the practice to make the cards in sheets four inches wide, and long enough to cover the width of the machine, but this has been abandoned in favour of a plan by which they are made in long strips or "fillets." These are long enough to completely cover the cylinder, on which they are wound in a way which will be hereafter described. Having obtained the fillet for the foundation, the next step is to introduce the wires. These are produced from a reel of specially drawn steel wire, which is frequently hardened and tempered by a continuous process. It is essential in conducting the latter that the wire should be free from scale, and, in the great majority of cases, this is attained. In fixing the wires into the foundation the preliminary step is to cut off from the wire carried on a reel a sufficient length, and bend it up into the form of a right angled staple, having two parallel arms joined by the third side. The extremities of these arms constitute two of the points to be fixed in the foundation, so that it will be seen these are always introduced in pairs, and not singly. In order to facilitate their passage through the foundation, two holes, pitched to correspond with the distance of the two points apart, are pierced in it, and immediately on the withdrawal of the piercer the staple is pushed in, and forced up to its place. Almost simultaneously with this operation it is set—that is, is bent to an angle as shown in Fig. 85. After one pair of wire points are fixed the fillet is traversed, so as to introduce another pair at the required distance from the last one. When the width of the fillet has been filled with teeth it is moved a little lengthways, far enough to begin the next

line, and the direction of the carriage is reversed. It is highly important that the wire points should be set equidistant over the whole of the surface, so that when the cylinder is clothed, the regularity of the carding points will be unvarying. The whole of the operations of feeding, cutting, and bending the wire, piercing the fillet, forcing in the teeth, traversing and reversing the carriage, and traversing the fillet longitudinally, are automatically performed by a machine of great ingenuity, originally invented by Mr. J. C. Dyer. It is one of the best examples in the whole range of mechanics of the power of the cam, and works with great rapidity, being capable of fixing over 300 pairs of wire points per minute.

(156) The teeth can be set in the foundation in three ways—either plain, twilled, or ribbed, these settings being shown in Fig. 76, the dots representing the wire points, the back of the teeth being shown by the dotted lines. In the first case the teeth are in straight lines; in the second they are, as the name implies, set diagonally; while in the third they are in straight lines, but set so that they are in sets of three, each of which overlaps its predecessor. Generally, plain setting is very little used, fillets being commonly made ribbed, except in the case of the flat covering, which, when mild steel wire is employed, is usually twilled. In

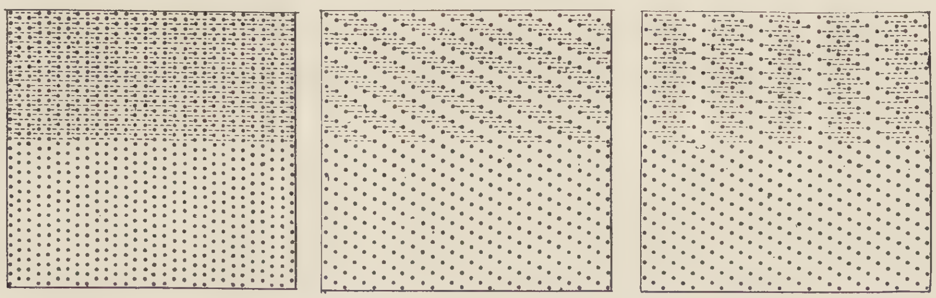


Fig. 76.

manufacturing cards for covering the flats it is common to commence with a large sheet equal in width to the length of the flat. The teeth are then set for a space equal to the width of the flat, when the sheet is rapidly traversed longitudinally until the point for starting a new flat strip is reached. These strips are cut out of the sheet, and thus leave the necessary margins for fastening to the flat. In America twilled setting is preferred, but, in this country, it is objected that spaces are left between each lap when fixed on the cylinder, which is very objectionable. This fault does not occur where ribbed fillets are used, and it is now almost the universal practice to use this setting for cylinder and doffing coverings. However the teeth are set in this respect, they vary also in their distance from each other, and this variation depends on the "counts" of the wire. This phrase is used to indicate the fineness of the pitch of the wire teeth, and the method of counting is based on the number of teeth in the width of the sheets formerly made. Thus, if there were 100 teeth in a sheet four inches wide, the counts were said to be 100's, the same rule being applied to-day. Longitudinally, the pitch of the teeth was ten "crowns," or points, to the inch, this being also retained as a standard of measurement. In this way it is possible, by knowing the counts of wire, to calculate easily

the number of teeth per square inch. Thus, in the instance named, there would be $100 \times 10 = 1{,}000$ teeth in the four inches of width by one inch in length, which is equal to 250 teeth in every square inch.

(157) In clothing the various parts of the machine experience has shown that there can be wise variations made in the kind used. Every spinner has ideas of his own, and as there is a wide difference in the class of material treated no rule can be laid down. In clothing the licker-in, a tooth which is known as the "Garnett" is universally used. An illustration of this is given, in full size, in Fig. 77, the finer tooth shown being used when no undercasings are fitted, and the coarser when they are. It will be noticed that the former is a little more hooked than the latter, which enables it to carry round the cotton without flinging it below the licker-in. The presence of an undercasing obviates much of the necessity for this carrying power, and the tooth is only required to beat off the cotton from the lap and thus throw down the motes, etc. In covering the cylinders of roller carding engines, where medium counts of yarn are being spun, clothing with 90's to 100's wire is used, the rollers being covered with the same counts, the clearers with a finer wire, and the doffers from 100's to 120's. These, of course, are sizes which are commonly employed, and indicate the usual limits, but, as has been observed, practice varies considerably in this respect. In revolving flat carding

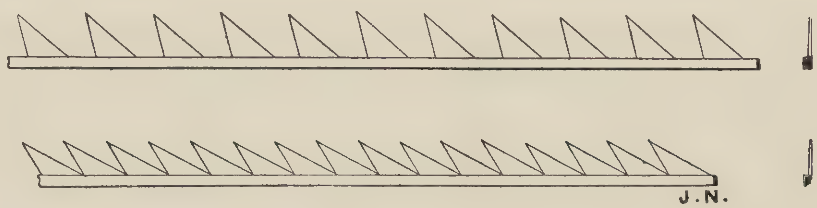


FIG. 77.

engines the cylinders are covered with 110's, and doffers and flats with 120's for medium counts of yarn. It may be generally stated that the finer the counts of yarn spun, all other things being equal, the finer the wire clothing employed; but it can only be settled by practice what are the best counts to use in any individual case.

(158) As has been observed, the wires are, in the process of setting, bent to an angle, or, rather, a double angle, after leaving the foundation. A reference to Fig. 85 will show that they leave the foundation at an angle in one direction, and afterwards bend sharply in the opposite direction. The diagram given in Fig. 78 illustrates this construction. The foundation is shown by the letter D, to which the line A B is perpendicular, leaving the upper surface of D at E. The tooth is indicated by the line A C E B^1, and it will be noticed that the point of the tooth at A is perpendicular to the point E where it leaves the foundation. This is the correct setting, or nearly so, for the following reason. Some makers, it may be stated, prefer to let the point A be a little behind the perpendicular line A E. In working, the wire point is pressed by the material and is sprung backward, in which case it—when set as shown—will radiate round E and move in the circle shown by the letters F A G. Thus, if another set of wire points are imposed upon the lower ones, the flexure of the

latter, in either direction, is followed by their recession from the former, and no danger exists of any interlocking, which, if it occurs, is injurious to both sets of teeth. As the relative positions of the upper and lower teeth are of the character described in the previous chapter, the adoption of the method of setting the teeth indicated is of considerable importance. It is, of course, possible to vary the angularity or "keen" as desired, and the more acute the angle E C A the more fibre caught and retained. Thus the proportion of waste made in a machine during work is largely dependent on the angular setting of the wires, and this is a point specially worth noting. The essential element is the approximate perpendicularity of the point A of the wire to that (E) where it leaves the foundation.

(159) With regard to the shape of the tooth a good deal can be said. Ideal carding would be obtained by the use of fine needle points closely set, as will be seen in dealing with the combing machine, but it is manifestly impossible to employ teeth of this description in a carding engine. Although they might be inserted and used in new clothing, as soon as they became blunt it would be impossible to restore their points owing to their position in the clothing. But the principle remains; and, failing the employment of needle points, the attention of makers has been directed to the production of a wire which will present to the cotton what is practically a needle—or more accurately—a knife edge, which can easily be renewed after wear. To Messrs. Ashworth Brothers belongs undoubtedly the credit of this important step, which brought in its train many changes in the general construction of the machine. They use a wire which is round in section, but which they grind at the side so that above the foundation it becomes oblong, thus presenting a sharp edge to the fibres while preserving all the necessary strength in the portion fixed in the foundation. Various other sections have been employed, such as double convex, triangular, and oblong, and by a special system of grinding the same kind of edge is produced. The teeth when fixed in the fillets are ground on their edges by thin emery disc wheels formed with bevelled edges, which pass between the teeth and grind them to a sharp edge. A pair of teeth of this character, magnified 13 times, are shown in Fig. 79, which is from a photograph lent by Messrs. J. Whiteley and Sons. It will be noticed that the line of the tooth is gradually tapered until the point, which assumes very nearly the character of a needle point, is reached.

(160) The question as to how far this "plough" grinding is a good thing is one which it is worth while dealing with at length. It is undoubtedly true that steel wire carefully hardened and tempered will, under equal conditions, wear longer than a softer variety, but it is sometimes argued that the advantage thus derived is counterbalanced by the grave faults often existing after a surface of this kind has been side ground. The idea of a needle point is the right one, but it is worse than useless unless the wire remains smooth. There are two evils to be guarded against—the barbing or hooking of the wire points and the striation of the sides of the teeth. Both of these faults are often produced in side grinding, this fact having been fully established by a number of investigations made by various observers.

(161) It is apparent that the abrasion of a wire surface by means of an emery wheel is sure to produce a certain degree of roughness. If any student of the subject will take the trouble to examine newly-ground clothing by the aid of a glass magnifying from 10 to 20 times, the scratches caused by the rotation of the emery wheel are easily seen. It requires very little reflection to show that this is sure to be

detrimental. Mr. B. A. Dobson, of Bolton, who has gone very extensively into the subject, published with an address delivered by him in America an interesting series of photographic representations of side ground teeth. These were enlarged a number of times, and were then reproduced. Striated sides and barbed points are common in this series. Now the inevitable effect of such a tooth is to break or destroy the fibre, or remove from its surface a portion of the waxy covering. This leads to an increased waste in the subsequent processes, although that produced in the carding machine may be less. It is hardly worth while discussing

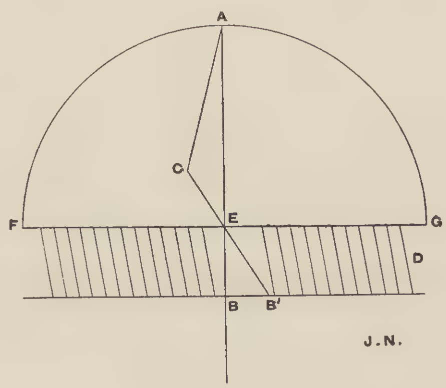


Fig. 78.

the point further, but there is one fact which speaks volumes as to the general opinion on the subject. It is agreed that the treatment of the teeth by those of a wire burnishing brush has a very beneficial effect upon them, and the carding afterwards carried out is much cleaner and better. This is one reason why the brush used to strip the flats is occasionally made of wire. As the action of a burnisher is to remove scratches previously made, its use is a confession of their existence.

(162) The roughening of the wire teeth is not, however, inevitable. In Fig. 80 is shown a side view of a plough ground tooth magnified 32 diameters. In this the striations are most marked, and there needs no comment to demonstrate their existence. In Fig. 81 a similar tooth ground in a special manner, and similarly enlarged, is shown. The surface of this is so much smoother than the other, that practically it is perfect. At any rate it is so much better than the one shown in Fig. 80, which is ground in the usual way, as to be an entirely different article. Both of these photographs are supplied by Messrs. John Whiteley and Sons, and the system of grinding by which the tooth shown in Fig. 81 was obtained, is now in regular use by them. The objection is not to needle or chisel shaped teeth side ground, but to these plus striation, and if the addition can be removed, many of the objections rightly entertained will be obviated.

(163) When the clothing has worn it is desirable to grind it frequently but lightly. The practice of allowing the tooth to become very blunt prior to grinding is very objectionable, as it leads to heavy grinding and there is a danger of hooked teeth. It is impossible to state a general rule on the subject, as the periods of grinding depend so largely on the class of cotton treated, but it is better to give a light grinding to the wire every few weeks.

(164) In the last chapter, in paragraph 107, it is pointed out that the cylinder is drilled with a number of holes arranged in straight lines across its periphery, in which wooden plugs are tightly driven. These are intended to aid in fastening on the fillets, and before clothing the cylinder or doffer, it is desirable to mark the centre of each line of holes on each edge, and to set out the position of each hole in one line on a staff. In this way, when the surface is covered, the exact position of each plug can be ascertained, and the tack inserted without damaging the wire. As the cylinder surface is quite level, the fillets are in some cases wrapped on the bare face, but there is some danger of the clothing slipping, especially if made with a rubber foundation. To obviate this serious defect, the surface of the cylinder is covered with a specially woven cotton cloth, or with brown paper, the former being preferable. This covering is put on without any puckers or creases—a very essential thing—and is attached to the cylinder by a special kind of cement or paste. On a surface prepared in this manner rubber foundations will not slip in working. With fillets in which the foundation is a woollen one, these precautions are not necessary. If it is intended to employ rubber foundations, great care must be taken before proceeding to clothe the cylinder. The fillets must be kept in a room heated to the same, or a little higher, temperature than the card room in which they have to work. This treatment causes the fillet to expand to a certain extent, and should be continued for some hours prior to their being used. Thus when the fillets are fixed in their position they do not expand as they would do if kept in a cold room before being used. Woollen foundations do not expand by heat, and can, therefore, be used and fixed without the preparation named. For this reason they are suitable for employment in places where the direct sunlight can fall on them. Oil being detrimental to india-rubber, fillets with that foundation should never be used where oil is likely to fall on them. A certain disintegration of rubber foundations occurs in some cases in hot climates, but they are largely used in England.

(165) Having prepared the fillets for wrapping on, the operation is completed. Formerly they were wound on manually, but this is now almost invariably done automatically by a machine made by Messrs. J. Whiteley and Sons, which is illustrated in Fig. 82. One end of the fillet is securely fixed, and the cylinder is then started. The cross slide K is fixed on the frame of the machine, or on a special frame if preferred, when the doffers are being clothed, and the apparatus is then ready for work. On the slide K a carriage is fitted which is traversed by a screw, on the end of which is a chain wheel L, by means of which the necessary movement can be given from the chain-pulley O automatically, or it can be manually given by the handle R. The carriage bears a drum mounted on a cradle hinged to the carriage. The angular position of the drum is regulated by the tension screw, and the tension put upon the fillet, in pounds, is registered by a finger moving over a graduated scale. The card fillet is taken from the basket through the trough D, thence over the drum, from which it is taken to the cylinder. The cylinder is revolved by means of the handle R, and the card clothing is slowly wrapped on, the traverse of the carriage being arranged to be at the required speed. In lieu of the drum Messrs. Dronsfield Brothers use a stepped cone, which gives a similar result. Thus, cylinder fillets, when made of hardened and tempered wire, can be wound under a tension of 270lbs., while doffer fillets of the same quality only require one of 175lbs., and

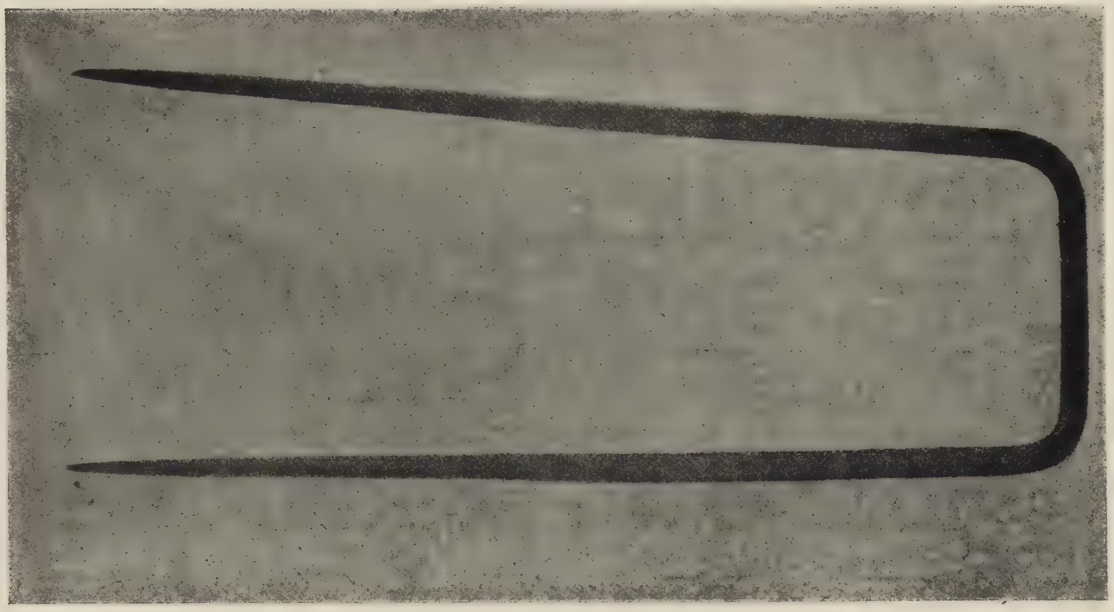


FIG. 79.

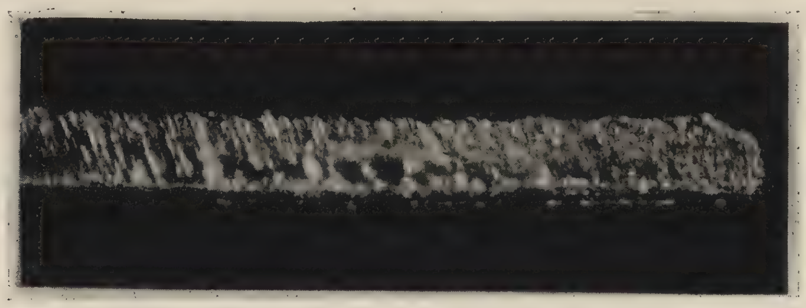


FIG. 80.

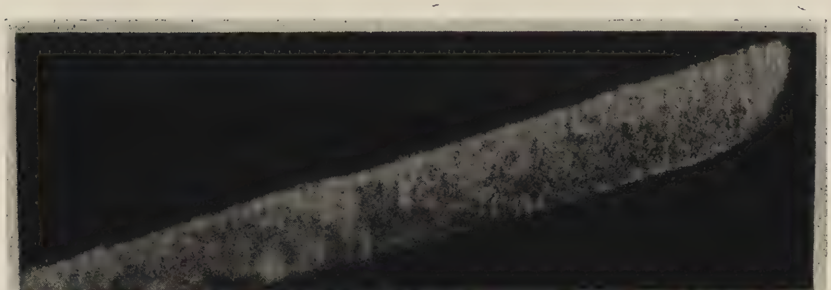


FIG. 81.

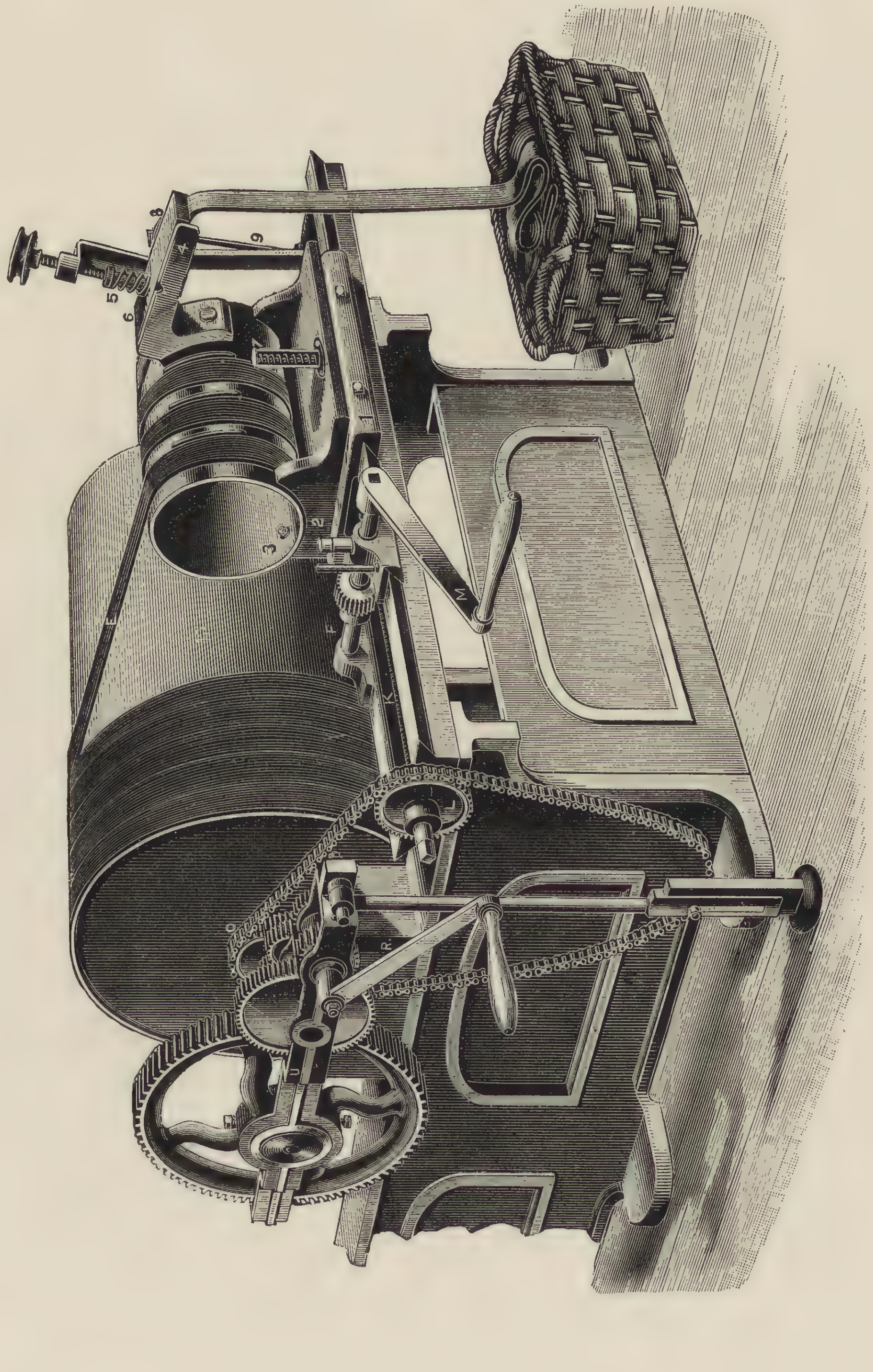


Fig. 82.

for roller fillets, which are only 1 inch wide, 120lbs. is sufficient. What is required is to so wrap the fillets that, without straining them, they adhere closely to the surface of the cylinder or doffer; and do not, after working, rise in places or "blister," as it is called. After the cylinder is covered the fillet is fastened at its free end, and is then allowed to rest for a few hours, so that it adjusts itself throughout its length. It is necessary to shape the fillet at each end so that, when wound, no break in the carding surface occurs; and, for this purpose, it is usually cut to a shape which permits the first and second coils and the last two to lie close together. It is then tacked on in the way previously described, a special tool being used to drive the tack and avoid damaging the wire.

(166) In fastening the clothing upon the flats several methods are pursued. A reference to Fig. 83 shows two of these. In A, which is 2 inches wide, and B, which is $1\frac{5}{8}$ inches wide, the edges of the flats are drilled with small holes, and the strip of clothing is similarly punched. One side of the strip is then

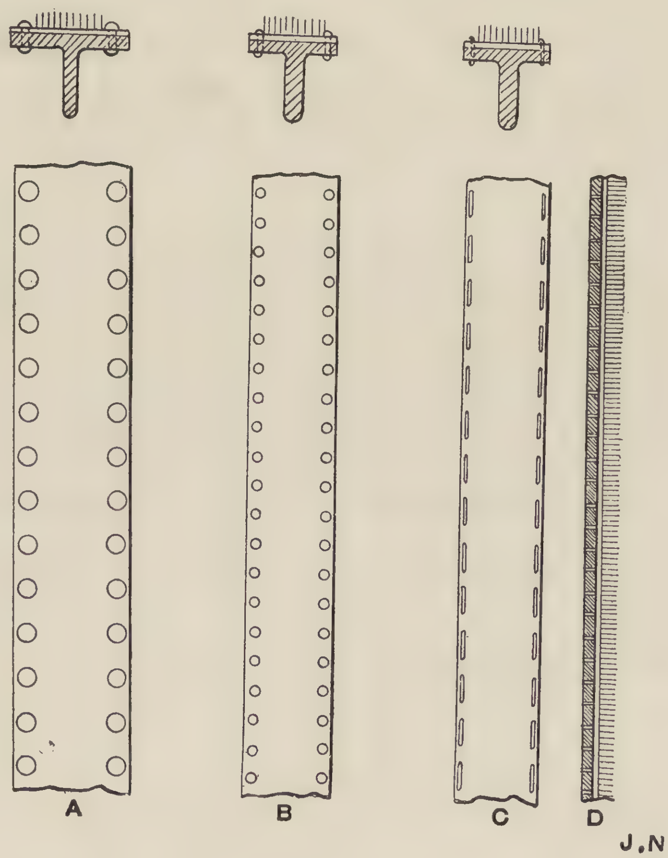


Fig. 83.

fastened to the flat by means of lead rivets, and it is then drawn tight along its whole length by a special clip. The other edge is, while the strip is held in tension, riveted firmly in a similar manner. A machine for this purpose, made by Messrs. Dronsfield Brothers, is shown in Fig. 84. Another method is one originated by Messrs. Ashworth Brothers, and is shown in C and D. In this case the strip is attached by means of wire

stitching, the flat being sawn at its edge at regular intervals, as is very clearly shown. A third plan is illustrated in Figs. 85 and 86 in partial perspective and transverse section, this being made by Messrs. John Whiteley and Sons. A clip is passed through the clothing and flat, and is then clenched, as shown separately in Fig. 87. The strip of clothing is then drawn tight, and the second clip fixed in the same way. This method is rapid and effective, and possesses one important advantage. By it the margins of the flat strip are protected from being frayed by the revolving brush used to clean them.

(167) In dealing with the construction of the flats it has been shown that there is a movement towards the use of shorter ones, for the reason that it is felt to be desirable to prevent any deflection by having a stiff flat. Upon this point the consideration of the advantages of various systems of fastening the clothing largely turns. It is quite clear that any removal of metal, either by drilling or sawing, is likely to weaken the flat. It is, however, not so readily seen which is the most weakening, but actual experiments show that wire sewing is so. Mr. B. A. Dobson, of Bolton, has made a series of tests of flats, both drilled and sewn, to ascertain the deflection during working and grinding positions, and the side deflection. These establish very clearly the superior strength of the riveted flat, which is very considerable. For instance, a flat $45\frac{5}{8}$ inches long by $1\frac{3}{8}$ inches wide, with the same thickness in flat and web, gave the following deflections when loaded with a 1lb. and 2lbs. weight respectively. Unclothed, sawn for wire sewing: 1st, when face up, $\frac{1}{380}$th and $\frac{1}{200}$th inch; 2nd, when on its side, $\frac{1}{330}$th and $\frac{1}{165}$th inch; and, 3rd, when face downwards, $\frac{1}{660}$th and $\frac{1}{400}$th inch. Unclothed, drilled for rivets, the deflections in the three positions named were as follows: 1st, $\frac{1}{1000}$th and $\frac{1}{500}$th inch; 2nd, $\frac{1}{450}$th and $\frac{1}{275}$th inch; and, 3rd, $\frac{1}{875}$th and $\frac{1}{450}$th inch. The reason for this is not far to seek. The riveted flat has throughout its length an unbroken metallic surface along its edge, while the sewn flat is broken at intervals to permit the passage of the wire. For the reasons given in paragraph 118, the difference between $\frac{1}{660}$th and $\frac{1}{875}$th inch is material, especially when the settings of the flats are supposed to be regulated to the $\frac{1}{1000}$th inch.

(168) In Fig 88 is illustrated a plan by which the necessity for piercing the flat either with holes or nicks is entirely obviated. This is patented by Mr. Tweedale, manager for Messrs. Howard and Bullough, and consists in the employment of a metallic clip, which grips the clothing at one side, and is bent round and under a small rib on the underside of the flat. The clip is closed by means of a special machine, which runs rapidly along the flat, the two sides being gripped simultaneously, and the fillet stretched by the same machine and at the same time. With this construction the maximum strength of the flat is preserved throughout all its positions and under all working pressures. A similar arrangement is used by Messrs. Ashworth Brothers, but the shape and construction of the clip and the method of fixing slightly varies from that described. It is to be noted, however, that the width of the flat strip must be rather less in each case than that of the flat, and that the strip must in consequence be stretched so as to cover the surface. It is essential that the clips shall be fixed so as to be in contact with the planed edge of the flat throughout its entire length. The edges of the flats ought to be quite straight, especially if they are closely pitched, as otherwise they would come into contact in places. If, therefore, the clips referred to are not pressed closely against the sides of the flats throughout their entire length the danger of touching is increased.

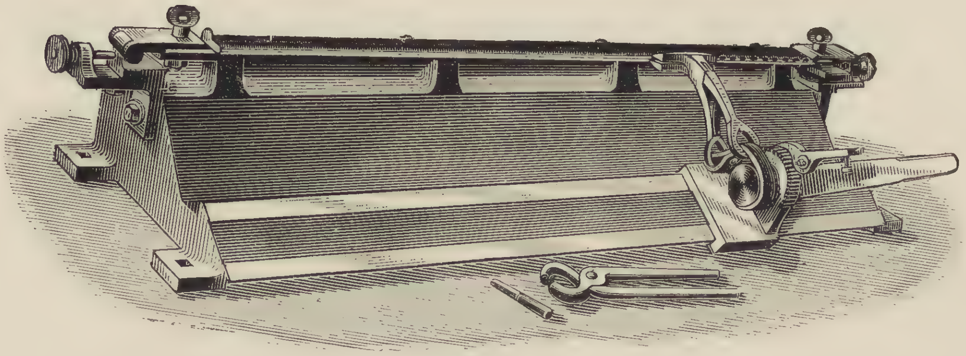


FIG. 84.

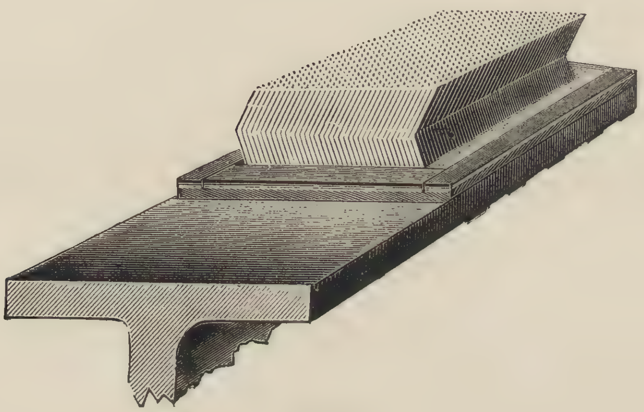


FIG. 85.

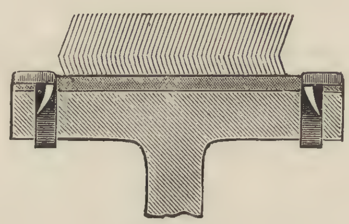


FIG. 86.

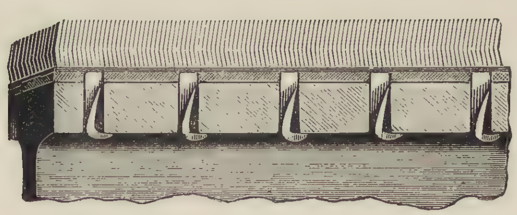


FIG. 87.

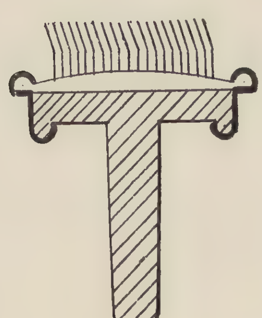


FIG. 88.

(169) Messrs. Platt Brothers and Company have recently devised a fastening of tinned wire, which is bent up by special machinery so as to form a continuous series of staples, the pitch of the points of which is about $\frac{1}{2}$ inch. The staples are connected at the points, so that a length can be produced sufficient for fastening any flat. Holes are drilled in the flat through which the staples are pushed, and are pressed downwards and held. While in that position the points are clenched similarly to Messrs. Whiteley's clip, and the clothing thus secured. This arrangement is practically a system of sewing without the disadvantage arising from the sawing of the edge of the flat. A strength equal to a riveted flat is obtained, with the advantage of a continuous grip along the flat strip. All these arrangements, however, imply the use of special machines to fix them, which is a condition not always attainable in a mill. For these reasons, where it is difficult to return the flats to a machinist for re-clothing, the use of rivets is most desirable.

(170) No less important than the proper fixing of the clothing in position is the operation of grinding it before starting work and after the points have worn. The licker-in is not ground, as the teeth do not require it, and their shape is such that grinding is impracticable. The cylinder is ground in position, and the question as to which is the correct method is one about which there is a good deal of controversy. In theory it is quite true that the periphery of a cylinder revolving, say, 180 times per minute, will tend to follow a path which is not an absolutely true circle. Further, the vibration set up in working, and the constant tendency from centrifugal action for the cylinder to roll forward, have a certain bearing on the subject. For these reasons there are some persons who contend that during the grinding of the cylinder teeth the cylinder should be run at its normal velocity, and the emery grinding roller be driven at a surface speed approximating to that of the cylinder. While this contention is theoretically correct, the disturbance caused by the high velocity of the cylinder is not of practical moment, and it is found to give the best results to run the cylinder slowly and the emery roller quickly. In all operations in which a true surface has to be established these conditions are found to be the best, and the grinding of a carding engine cylinder forms no exception to the rule. The danger of damage to the wire joints is much less likely, and the high speed of the grinder aids materially in light grinding, which it will be shown is of great moment. It is, therefore, the universal practice to reduce the normal speed of the cylinder to one varying from 7 to $1\frac{1}{2}$ revolutions per minute, and several special devices are in the market for the purpose. Before passing on to describe these, it may be said that the cylinder is ground by an emery roller, sustained in special brackets fitted to the machine framing, the position of which is shown in Fig. 44 at R. A similar method of procedure is adopted with the doffer, the brackets being placed at S.

(171) The most common appliance to obtain a slow motion of the cylinder is that known as Sykes', which is shown in Fig. 89, as made by Messrs. Dronsfield Brothers, of Oldham. This consists of fast and loose pulleys, which are driven by a strap from a pulley on the line shaft. The pulleys are sustained in a frame which also carries a short strap, on which is fastened at one end a bevel and at the other end a worm. The frame is supported by the two legs shown, which can be adjusted to any length. The worm wheel is fixed on the cylinder shaft in place of the ordinary pulley, and is driven by the worm and

gearing as described. A slow motion is thus given to the cylinder, and at the same time the grinding rollers are driven by bands or cords from grooves formed in a flange on the fast pulley.

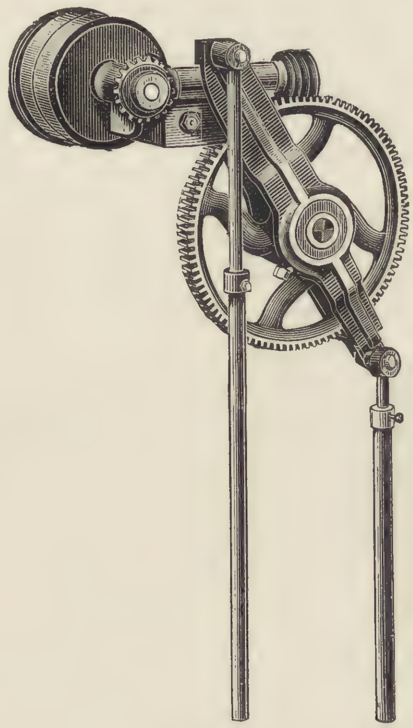


Fig. 89.

(172) A motion patented by Messrs. John Hetherington and Sons is illustrated in Figs. 90 and 91. In Fig. 92 a side view of a carding engine is shown, with the motion applied to it. On the stud G, which usually carries the intermediate band pulleys, shown by the dotted line I, the boss F of the supporting frame A is fitted. The apparatus is shown in Fig. 90 in section, and consists of the supporting frame named, the

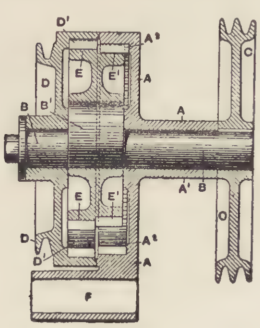


Fig. 90.

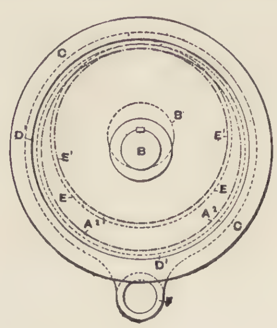


Fig. 91.

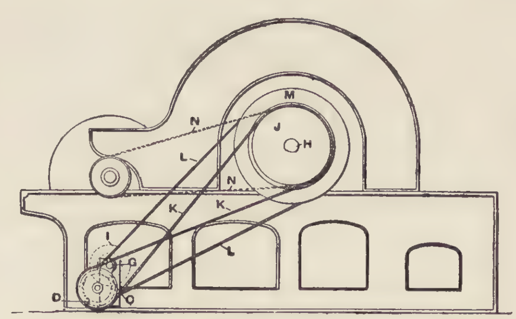


Fig. 92.

boss A^1 of which forms a bearing for the shaft B, with the eccentric B^1 formed on it. On one end of the shaft the double grooved pulley C is fixed, by means of which it is revolved. An internal rack A^2 is formed on the fixed frame A, and adjoining the latter is the compounded pulley D. D is also formed with an

internal rack and a single grooved pulley, and revolves on the outer end of the shaft B, being kept in position by the nut and washer shown. There are thus two racks, each containing the same number of teeth, one fixed and the other free to revolve. Mounted on the eccentric B^1 are two wheels E E^1, the latter being smaller in diameter than the other, this arrangement being shown clearly in front view in Fig. 91

(173) The action of this mechanism is as follows: The pulley C is driven by a band K passing over the pulley J on the main cylinder shaft H. In this way C is revolved, and the eccentric movement of the shaft B causes the wheel E^1 to fall into gear with the rack A^2. This gives a rotary motion to the wheels E E^1, and the larger diameter of E causes it to revolve at a greater rate than E^1. The revolution of B, in addition to setting up this rotary motion in the compound wheel E E^1, also puts E into gear with the rack D^1, and causes the latter to revolve. The motion of the pulley C is thus communicated to D, but the latter is revolved at a much slower velocity in the direction of the shaft. By proportioning the pulleys and wheels the necessary reduction in speed can be obtained. The revolution of D is communicated to the cylinder by the band L passing over the grooved pulley M.

(174) In the machine as made by Mr. Samuel Brooks, the motion is compounded with the barrow wheel detaching motion, as illustrated in Figs. 93 and 94. On the same stud as the barrow wheel is a helical wheel C, which is driven from the former by a clutch, and which engages with a wheel D fastened on the

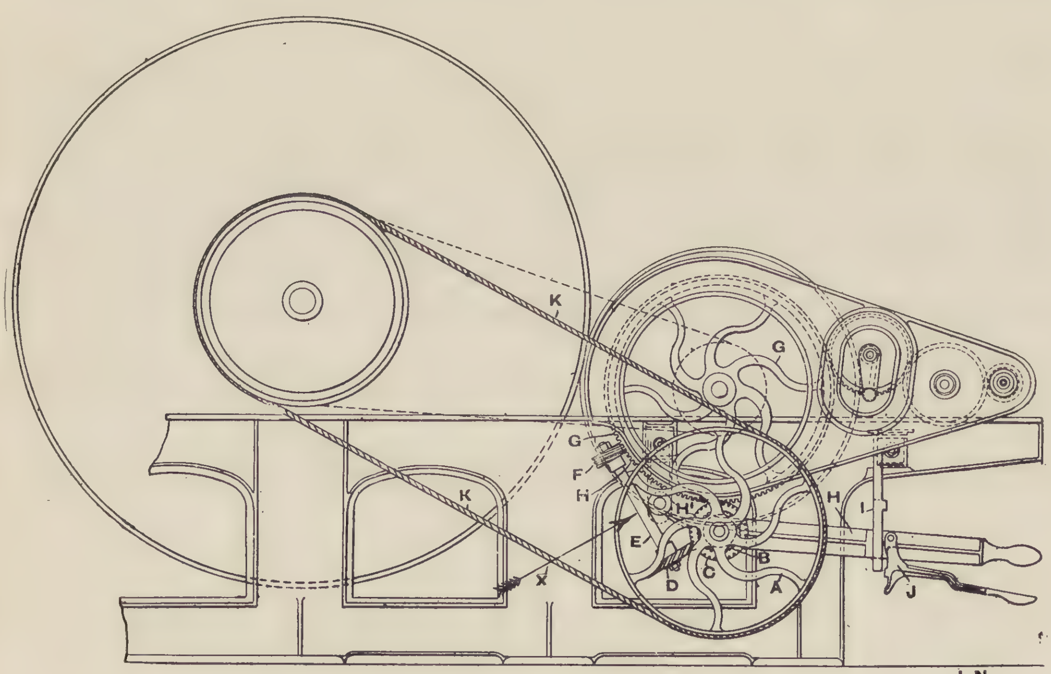


FIG. 93.

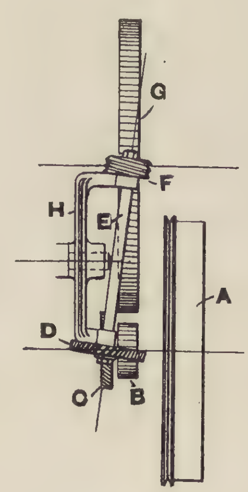
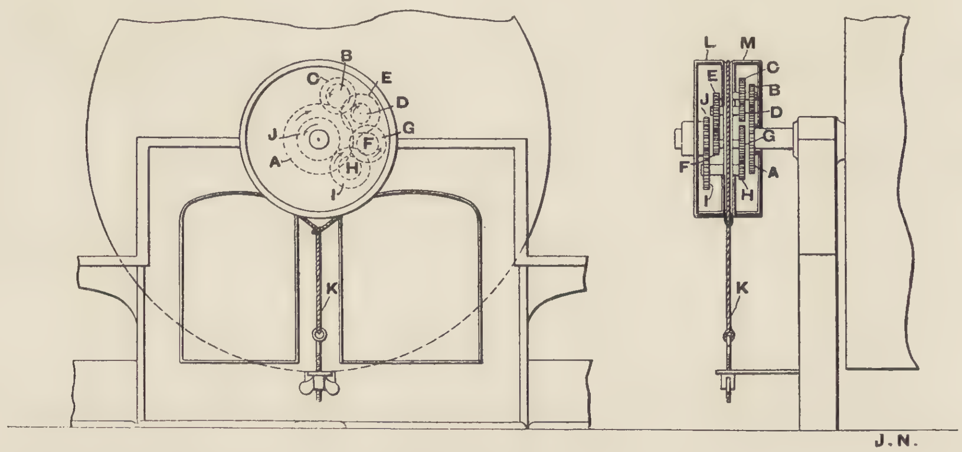


FIG. 94.

lower end of a shaft placed at an angle of 97°. On the other end of the shaft a worm F is fixed, and gearing with the wheel G. During grinding the barrow wheel is disengaged by means of the lever in which the stud carrying the former is fixed, and the worm is thrown into gear. The speed of the cylinder is thus

reduced to about one revolution, the necessary rotation of the wheel C being obtained from the pulley on the cylinder shaft. When it is desired to grind the cylinder the strap is thrown on to the pulley, and the necessary rotation given to the barrow wheel B and helical wheel C. The arrangement thus described is always in position, and does not require separately attaching to the machine, as is the case with most of the motions in use.

(175) Another form of apparatus recently introduced by Mr. Thomas Knowles is the one shown in Figs. 95 and 96. In this case the boss of the loose pulley L carries a pinion J inside the pulley which gears with I, fixed on a short shaft borne by a central plate. Through the train of wheels H G F E C and B the central pinion A, fastened on the inner boss of the fast pulley M, is revolved. Over the central plate, in which the spindles on which the wheels E F G H and I are fixed, are fitted, a band K is passed. By tightening the latter



FIGS. 95 AND 96.

the plate can be prevented from revolving. In grinding, the strap is moved on to the loose pulley, the band K is tightened, and the revolution of the pulley gives motion to the whole of the wheels, thus reducing the ultimate velocity to the required extent. During work the band K is slipped off the plate, and the whole nest of wheels is carried round with the pulleys as they revolve.

(176) The rollers used for grinding the cylinder and doffer are made in two forms. One of these is shown in Fig. 97. It consists of a light roller made with a thin wrought iron shell secured upon a shaft,

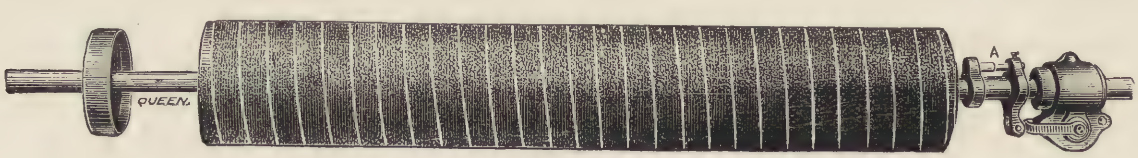


FIG. 97.

running in brackets fixed to the frame side. The driving pulley is fastened at one end, and at the other is a traverse arrangement, consisting of an eccentric rotated by a worm on the shaft. By means of a short rod

the revolution of the eccentric gives a small lateral movement—about an inch—to the roller during the whole time it is in motion. The surface of the roller can be covered with emery in the ordinary manner, and is either made plain or grooved. Another method adopted by Messrs. Dronsfield Brothers, is to wrap round the roller a narrow fillet of emery cloth, either plain or grooved as desired. In covering, one end of the fillet is passed into the slit Fig. 98, and is then secured by the clamp shown. About half of the width of the

Fig. 98.

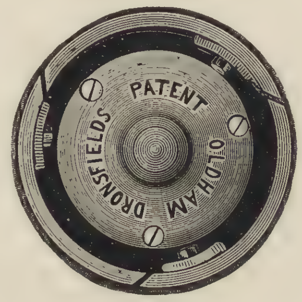


Fig. 99.

fillet is left projecting, and after it is secured, it is wound on by revolving the roller. As soon as the fillet is wound its loose end is passed into one of the three slits Fig. 99, formed at the other end of the roller, and is secured by the clamps. The ends are then trimmed off, and the roller is ready for its work. The grooved covering is preferred by many carders, as it is found to grind the wire teeth better, and to meet the various requirements of the trade it is made in various degrees of fineness. Three of these are shown in

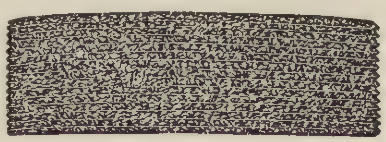


Fig. 100.

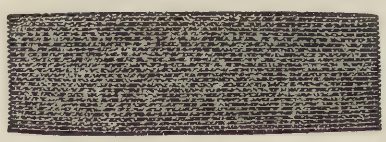


Fig. 101.

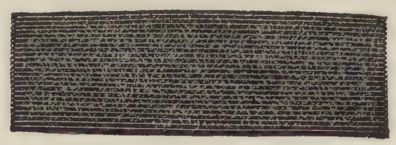


Fig. 102.

Figs. 100, 101, and 102, the coarser of the three being used for mild steel or iron wire, and the finer variety for hardened and tempered wire. All the rollers are carefully made, so as to be evenly and truly balanced, and great care is taken to ensure them having a perfectly true surface on which to wrap the filleting. This method of covering rollers has a good many advantages, the chief of which is the ease with which the operation can be conducted as compared with the older method of covering.

(177) Another form of roller is shown in Fig. 103, this being a modification of the Horsfall type. It differs from the one previously described, which covers the whole width of the surface to be ground, whereas the Horsfall roller is a narrow roll to which a rapid reciprocal movement is given across the surface of the wire. It consists of a light shaft, in which is formed a straight groove for the greater part of its length. In the bottom of this a zig-zag groove is formed, into which a fork enters. The fork in the roller shown in the illustration is mounted in a plug fitted into the boss of the grinding roller, and can be removed and

replaced without difficulty. Oil pads are fitted at each end of the grinding pulley, and are covered with brass caps, so as to keep them in position. In this way the parts are always efficiently lubricated, while at the same time grit and dirt are excluded. The emery roll or pulley is traversed as described by the engagement of the fork and the spiral groove, and as soon as it reaches either end of the longitudinal groove, it is automatically reversed. This action takes place throughout the whole period of grinding. On the whole, the

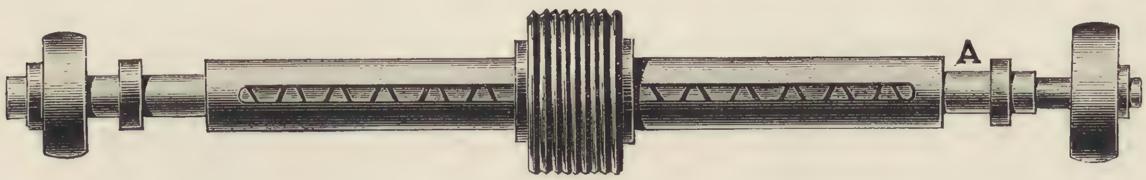


Fig. 103.

employment of the Horsfall type of roller is not so great as that of the continuous roller shown in Fig. 97. When the latter is used all the teeth are ground in a straight line across the cylinder, while the use of the Horsfall implies the grinding of the teeth in a spiral line over the whole surface. It is quite true that the whole of the teeth are ground in either case, but there is an obvious advantage in treating all those in the same line at one time.

(178) In grinding the cylinder the cover above the doffer is removed, and the wire surface bared. The cylinder is then stripped in a way which will be afterwards described, and the roller is fixed in brackets R, Fig. 44, placed to receive it. The construction of these brackets is a matter of importance. They are accurately planed, and fitted so as to move to and from the cylinder centre in radial lines. They must be so fixed to the bend or framing that they are quite level and parallel with the surface of the cylinder or doffer, as otherwise they would grind more off the wire at one side than the other. This is an essential feature, and it is also required that they should be set so as to grind lightly, otherwise there is a danger of producing hooked teeth, which are very detrimental to good work. Generally, the remarks just made apply also to the grinding of the doffer, which is effected by means of the brackets S, the doffer cover being removed, and the doffer stripped.

(179) The grinding of the flats in revolving flat engines is usually performed by a roller sustained by the brackets T, which are fitted on the side nearest the cylinder, with a surface against which the flat end is pressed by the weighted levers shown. The accurate grinding of the flats involves a nice problem which is worth a special explanation. As was stated in the last chapter, paragraph 117, the flats are formed with a heel which throws up the edge nearest the licker-in, and thus prevents any rolling up of the fibre. In Fig. 104 a diagrammatic representation of the relative position of the flat end and wire surface is given. The flat end is shown by the letters A B C D, and the wire by C D E F. It will be noticed that the line E F is not parallel with A B, which represents the surfaces on the top of the flat ends, but is parallel with C D, which represents the surface on which the flat travels. It is obvious that if during grinding the flat is held against a prepared surface, by means of its face A B, and traversed

thereon, there will be a corresponding formation of the face E F of the wire, which would become parallel with A B. If this happened, the whole object of reducing one of the faces on the surface C D would be destroyed, as while the heel would be in that surface it would be removed from the wire face. But if, on the other hand, the flat is sustained on the face C D during its passage under

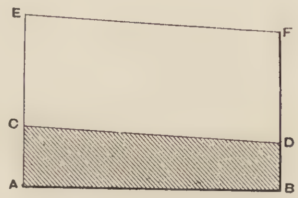


FIG. 104.

the grinding roller, the parallel relation of C D and E F is not altered, and therefore the flat is as fit for its work as before grinding. How to sustain the flat when being ground so as to maintain this parallel position is the problem, which is, however, in a fair way towards solution. The steady, forward movement of the flats during grinding somewhat increases the difficulty, but as it is one of the necessary elements of the case it must be duly taken into account.

(180) In Fig. 105 an illustration is given of an arrangement patented by Messrs. Knowles and Tatham. The grinding bracket carries a pivot on which the weighted lever F oscillates. The unweighted end of F presses against the top side of the flats as they are successively brought within the sphere of its influence,

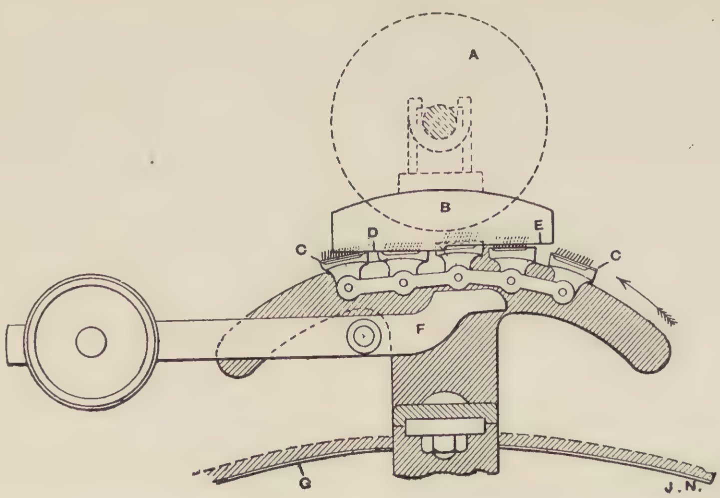


FIG. 105.

being of course turned upside down at this point. A plate B is fixed in the position indicated, being of sufficient width to engage with the flat end without touching the wire. B is, as shown, formed with a shoulder, the difference in the height of the two planed surfaces, D and E, thus obtained being equal to the

heel of the flat. The grinding roller is indicated by the dotted line, as is also the bearing. The position of the shoulder on B is such that the whole of the wire has been ground before the flat end passes over the shoulder, and the flat is thus kept approximately in correct position for maintaining the parallel relation of the wire and working faces. Before the wire on the succeeding flat begins to be ground, one of the ridges on it passes on to the lower surface E, so that the wire face is brought into a horizontal position.

(181) In Fig. 106 an arrangement made by Messrs. John Hetherington and Sons is illustrated. The ordinary grinding bracket is replaced by another one, fixed in the same position, which carries at its upper end a slide K. This moves in a bed prepared for it in the bracket, and has the necessary bearings formed

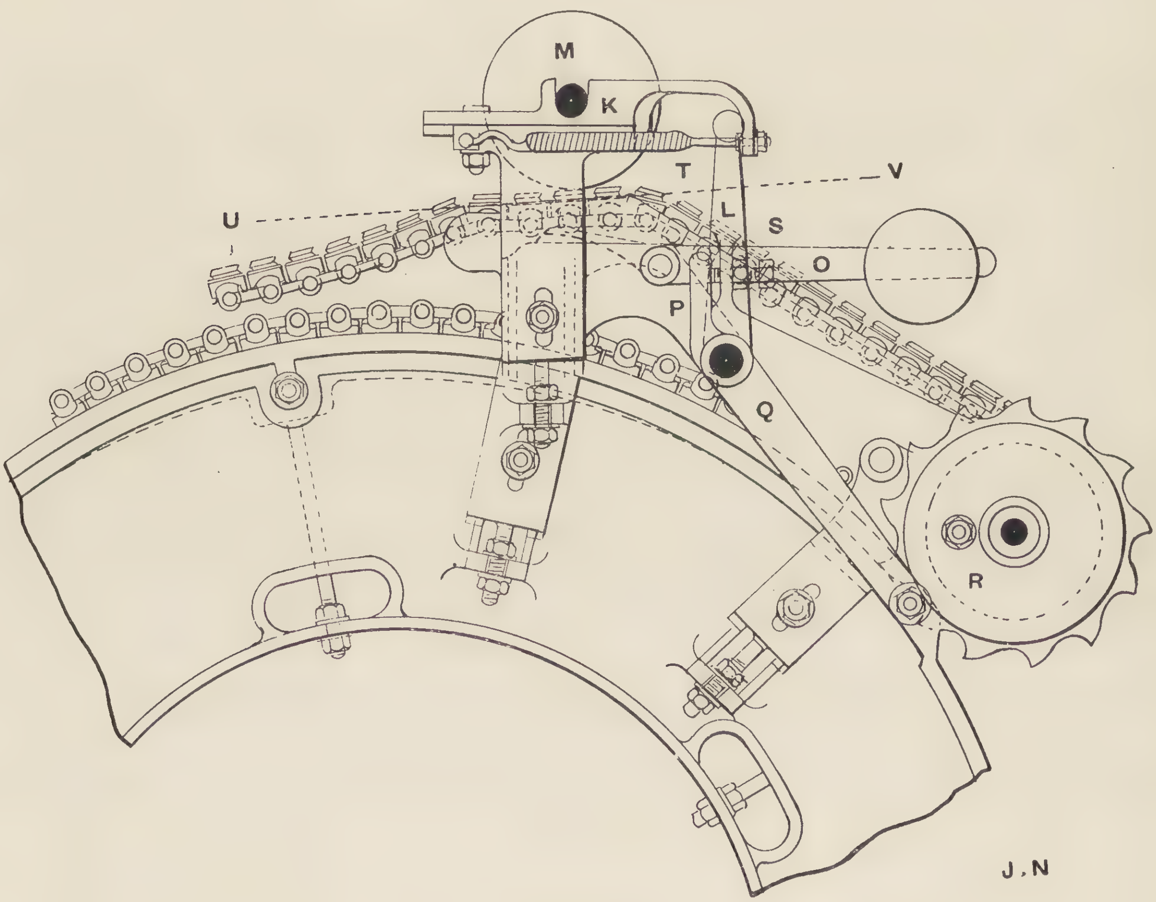


Fig. 106.

for the roller M. Attached to the slide K and the bracket is a spiral spring T, which always tends to draw K against a stop. The vertical lever L extends upward, and its upper end presses against the inner side of the horn of the slide K, so that when L is oscillated the slide is moved forward. On the same spindle, forming a centre for L, a lever Q is fixed, which has a vertical tail-piece P. A rib is formed on L

hrough which a screw is threaded, the point of which presses against the edge of the tail P, and is, when adjusted, locked by means of a nut. The flats pass beneath a plane surface fixed to the inside of the grinding bracket, and their working faces are pressed against it by means of the weighted lever P. The line of the flat traverse while so pressed is shown by the dotted line U V. When a flat enters upon the surface on the bracket it is pressed upwards, as described, and, while so held, the grinding bracket is moved forward over the teeth by the action of the cam R fixed on the chain roller shaft. The rotation of R depresses the lever Q, and gives the required movement to the lever L and to the slide K. It will be noticed that the slide K is placed at such an angle that it traverses to meet the flat, the object of this being to establish such a line of motion of the grinding roller as corresponds to the inclination of the flat relatively to the cylinder during work. The roller traverses in the opposite direction to that in which the flat moves for a certain distance, when it returns and again passes over the wire surface as that is moving forward. During the reverse movement it moves vertically to the same extent as previously made, so that in both cases it grinds the wire points in the desired plane, and thus maintains the true relative distance of both sets of teeth. By the time the reverse movement has taken place, the flat being ground has moved forward sufficiently to pass beyond the range of the roller, and the latter is then ready to grind the next of the series. In this device the principle of grinding by the movement through an angular plane of the roller axis is the central idea, and there can be no question that this is a very likely method of getting a true result. For it is obvious that if the flats were held stationary, and the roller traversed in an inclined plane, the necessary regularity would be given to the wire surface with great exactitude. A similar result is obtainable by similar means although the flats may be slowly moving, and this is demonstrated by the motion just described, which has been used with great success.

(182) In Fig. 107 is shown a side elevation of Edge's grinding apparatus, which is made by Mr. Samuel Brooks. Its essential feature consists of a curved plate B, which is fixed either to the grinding bracket A, or to a fixing attached to it. Over this the flats C traverse, and when they reach the centre the snugs at the back are drawn upon the raised portion B^1, which is sufficiently long to permit of each flat being in contact with it the whole of the time it is passing under the grinding roller. A plate D is maintained in a position above the flats, and the method of forming it and regulating its position constitutes one of the chief features of this arrangement. The grinding roller G is sustained by a bracket or bearing, in which its axis F rotates. The bracket rests upon a cylindrical stem E^1, fitting inside a cup, and also in a similar recess or barrel E. The latter has a long boss which forms part of, or is attached to, the plate D, and E^1 is screwed and fitted with two cylindrical nuts. Thus, by adjusting the nuts, the distance of the centre of F from the under surface of D can be varied at will, and the pressure of the grinding roller upon the wires fixed. The action of this mechanism is as follows: As the flats C traverse they ride upon the projection B^1, and their working surfaces are forced against the under side of the plate D. The latter is shaped so that the traverse of the flat causes one side of it to become depressed and the other to be elevated. The peculiarity of this arrangement lies in the fact that the change of position of the plane of the flat faces is

sufficient to ensure all the wire points being presented to the action of the grinding roller in their correct plane. In other words, the effect is nearly identical with that obtained when flats are held separately in a stationary frame, and the grinding roller passed over them. Not less important is the ease with which the position of the setting plate D can be adjusted relatively to that of the grinding roller. This power of adjustment is the chief feature of this mechanism, and as, when it is once made it is constantly maintained,

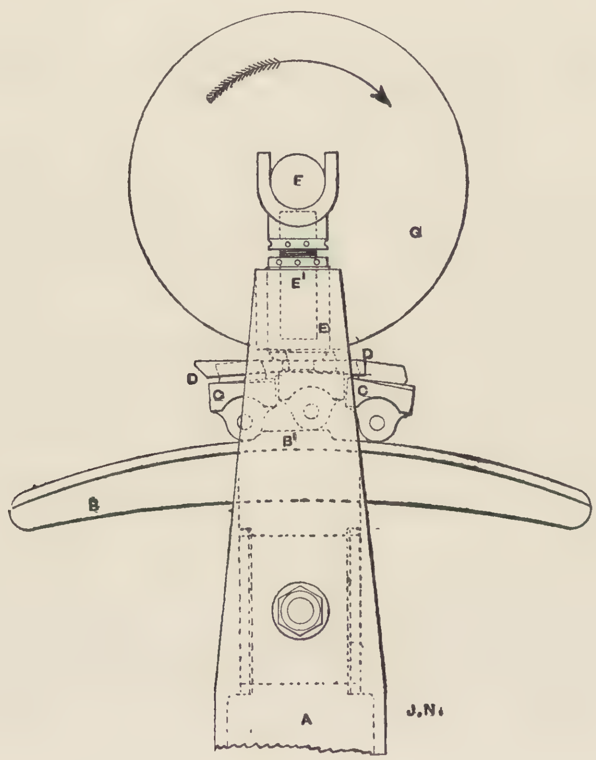


FIG. 107.

each of the series of flats will be so ground that the distance of its wire points from its working face will be identical with that of each of its fellows. Thus a set of thoroughly good flats is obtained, each of which is in the best condition to do its work. A further point which it will, perhaps, be well to mention is, that the power of adjustment, existing by reason of the two nuts shown, permits of the flat ends being subject to the required pressure during grinding, which is afterwards constantly maintained.

(183) Fig. 108 represents in partial section Higginson and Mc.Connell's patent, which has been adopted by Messrs. Dobson and Barlow. It consists of a bracket A fixed as usual to the machine framing, and having at its upper portion C a slot in which the small slide D is fitted. This slide has its underside shaped to the extent necessary to give the flats the required amount of inclination during grinding, and at the end of this surface is formed with a lip as shown. A spiral spring E is fitted in the slot, and presses

against the end of the slide when the latter is in its normal position. The flats G, of which there are only two shown, travel in the direction of the arrow, and when turned face up the chain lugs mount upon the nose of the short lever H. A bell-cranked lever F is fixed on the same shaft as H, its vertical limb having a set screw I fitted, by which its range of movement is limited, while its horizontal arm carries a balance weight. As the flats traverse they alternately mount upon the higher part of H, and are thus pressed into contact with the inclined part of the slide D. Immediately afterwards the flat comes in contact with the lip, which prevents its further forward movement. At this time it is in such a position that the wire surface is horizontal, and while in that position it is passed under the grinding roller B. As it traverses it carries the slide D along with it, gradually compressing the spring E until the wire has been entirely ground. When this has happened the slide makes a little further forward movement—its entire traverse being shown by the two vertical dotted lines—when the chain lugs pass off the nose of H, and the flat falls clear of the slide D. Immediately this occurs the spring E pushes the slide back,

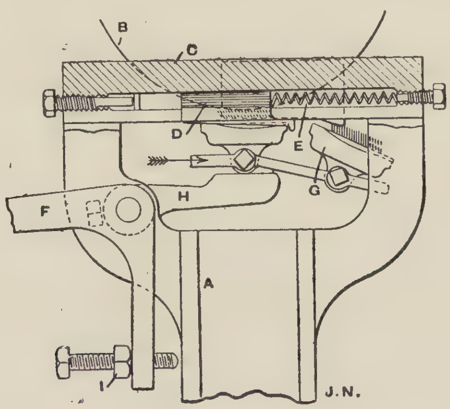


Fig. 108.

and it is ready to receive another flat. The chief feature of this motion is the employment of the sliding wedge. When the flat is pressed on to this it is held as though it was on a stationary bed, and is, by reason of the horizontal position of the slot, maintained in a constant plane. Thus the wire surface is presented to the action of the roller in a plane parallel to that of the slot, so that, whatever the variation in the flat end caused by wear, it is not affected. There is another point which is somewhat important. The tension upon the chain links caused by the friction of the flats upon the bend is very considerable, and results in a gradual lengthening of the pitch of the chain. If, in addition to this, the extra friction set up by the pressure of the lever H on the flat, thus causing the latter to be forced against the surface of a plate, be taken into account, this tendency to lengthen will be increased. The extent to which this is to be considered varies naturally with the pressure exerted. Although it is not perhaps great it is appreciable, and it is a matter to be considered. In Higginson and Mc.Connell's motion this friction is slight, as the slide D is arranged to move without much power, although the

compression of the spring towards the end increases the amount required. As the wedge springs back into position it has to slide over the face of the next of the series of flats, which by this time has passed upon the end of the lever H. Thus, although the flat travels forward without friction, there is a certain amount to be considered as the wedge is passing into position on each flat, the pressure being then exerted as in the case of a fixed plate until the flat presses against the lip, and the wedge begins again to slide.

(184) In Fig. 109 a side elevation of an arrangement made by Messrs. Platt Brothers and Company, Limited, is shown. In this case, also, the device of a sliding angular surface is employed. A slide H, which is guided in the upper part of the grinding bracket, and upon which a pull is constantly exercised

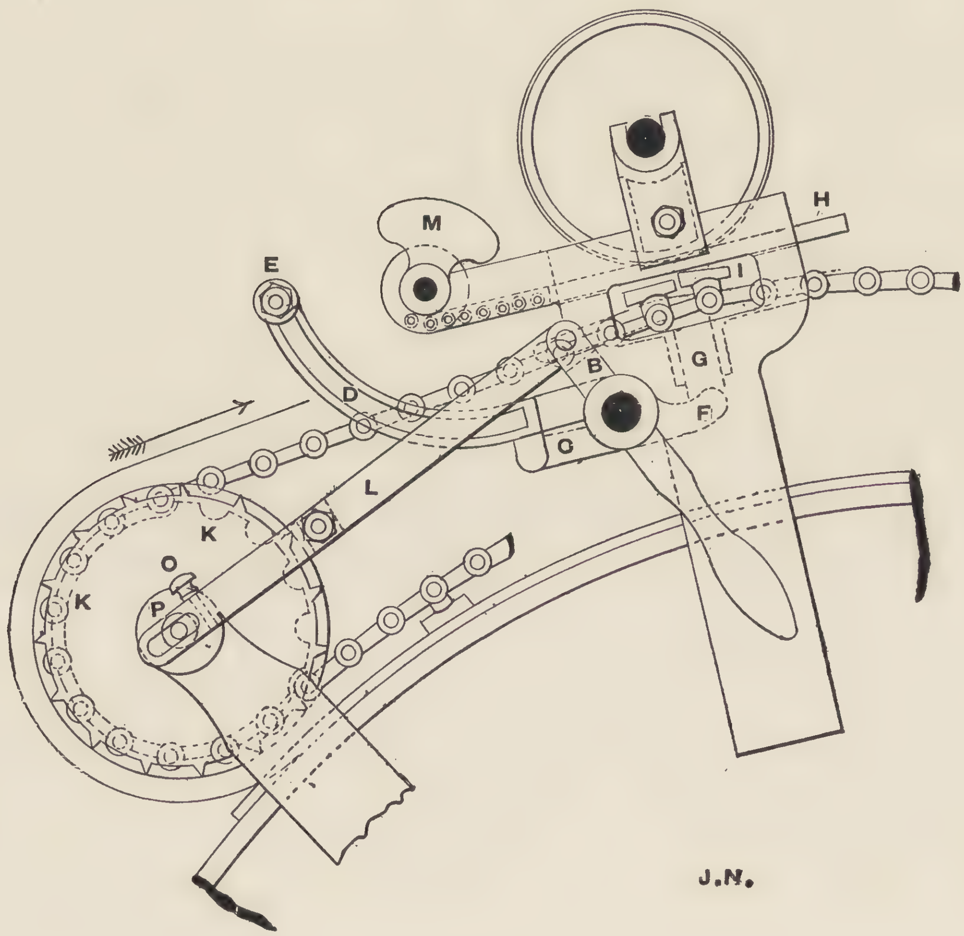


Fig. 109.

by the balance weight M and chain shown, has affixed to its lower side the angular or inclined surface against which the flat end is pressed during grinding. As in the mechanism just described, the surface to receive the flat is formed with a lip, so that the forward traverse of the flats causes it and the slide H to

move in the direction of the arrow. A slight curve corresponding to that of the bend is given to the sustaining surface of the slide, and the flat is thus held in a corresponding position to its working position. On the axle of the chain wheel by which the flat chain is driven is a toothed cam plate K, which is shaped as shown, so that it can give a forward movement to the lever L. The latter has fixed in it a tooth or catch, which constantly presses on the surface of the wheel K. The lever or bar L is formed with a slot at one end, with which a pin fixed in the end of the chain wheel axis engages, so that the lever can freely slide upon it. The other end of the lever is jointed to a lever B, fixed upon a short shaft on which is also fastened the short lever F and the curved arm D. There is a similar arrangement of mechanism at either side of the machine, and the two arms D are coupled by means of a round bar E, which acts as a weight. In this way a certain torsion is put upon the short shaft, and a tendency is set up in the lever F to move upwards. In doing so F presses against the slide G placed inside the framing and bend. The upper end of G when pushed up presses against the back of the flat and forces it against the inclined surface, where it remains until the flat is ground.

(185) The action of the mechanism is as follows: When a flat has passed under the grinding roller completely the rotation of the wheel K causes one of the teeth to push the lever L forward, and so oscillate the shaft upon which the lever B is fastened. This raises the arm D, and relieves the slide G of the pressure exerted by the weight E. The flat I at once falls out of contact with the surface of the slide H which is thus free to fall back into position to receive the next of the series, this being the position shown in Fig. 109. It is essential to notice that, while the backward movement of the slide H is taking place it is out of contact with the flat, so that, neither during its forward or backward traverse is there any extra tension put on the chain. Immediately the slide has completed its movement the engagement of the catch in L with the tooth in K ceases, and L is free to slide inwards, which it is caused to do by means of the weight E. At the same time the slide G is pushed upwards, and lifts the next flat into contact with the inclined surface on H. It only requires to be said further that the pitch of the teeth on K ensures the requisite movements being given to G to cause the latter to engage every flat in its turn.

(186) The rollers and clearers are ground after removal from their places in the machine. A machine of which Fig. 110 is a perspective view is employed for this purpose, this being the type made by Messrs. Dronsfield Brothers, who have specially devoted themselves to this class of machines. The machine consists of a frame which has bearings formed, in which the shaft of the grinding roller revolves. Affixed to the lower portion of the frame is a counter shaft from pulleys, on which the emery roller is driven at a speed of 300 revolutions per minute. The roller to be ground is borne by the two bearings shown, which are slid laterally by the extremities of arms secured to a transverse spindle sustained by brackets fixed to the framing. The two arms are moved to or from the frame by means of a hand wheel which is keyed on a short spindle, on which is also fixed a worm. This engages with a quadrant fastened on the transverse spindle, so that the rotation of the worm in either direction gives a movement to or from the grinding roller. In this way the card roller is brought into contact with the grinding roller equally over its whole surface, the axis of the

bearings in the arms being always parallel with those of the grinding roller. A bonnet is placed above the machine, and the dust is removed by the small centrifugal fan shown. The card roller is driven by a separate strap from the counter shaft.

(187) The flats of self-stripping machines are removed from the latter, and are secured on suitable bearings formed on the frames of a special grinding machine. The bearings are adjustable, so that the correct position is given to the flat during grinding. The faces of the flats when so held are moved across the grinding roller, which revolves at a high speed. As the arrangement is a very simple one, and does not present any great novelty, it is not necessary to describe it in great detail.

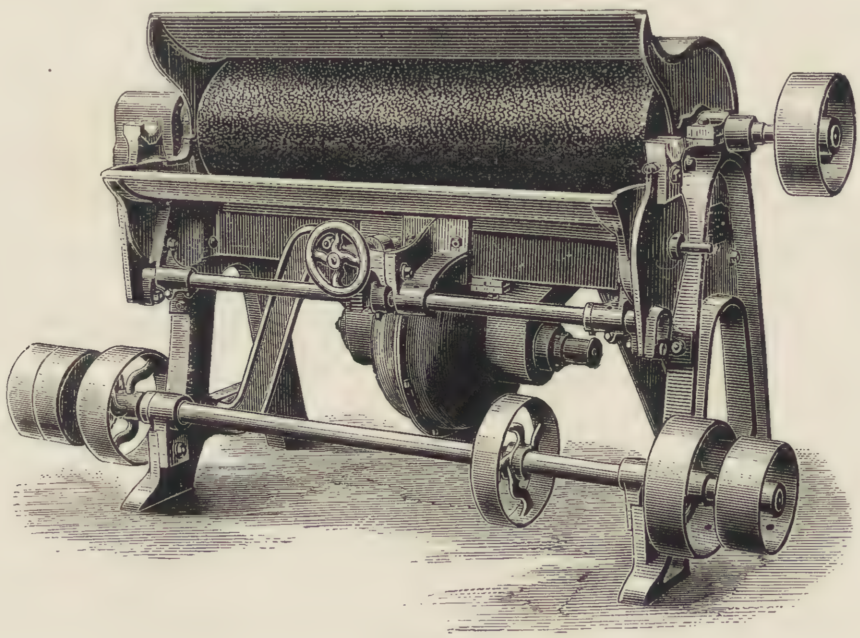


Fig. 110.

(188) As the wire clothing on the cylinder, doffer, rollers, and flats becomes filled with motes, neps, and short fibres, it is necessary to remove these periodically. This operation is called "stripping," and it is a very important one. Whatever may be said to the contrary, stripping cannot be dispensed with unless some specific be found for the removal of the impurities as fast as they are taken out of the cotton. The plan formerly adopted for this purpose has fallen into disuse, as it implied the stripping of the card during work, and led to the mixing of the stripping with the finished sliver. It has been shown that a clean wire surface is the best for carding, and it will be easily seen that the filling of the spaces between the teeth will materially reduce the elasticity of the wires. Regular stripping is for this reason advisable; but the ease with which, if so carried out, the dirt can be removed, constitutes a further reason for this procedure. Carding speedily becomes poor in quality unless this is looked to, and all spinners should carefully watch this point. Another matter is, that inasmuch as it is practically impossible to strip all the cards simul-

taneously, the operation should be effected so that there should be an equal proportion of clean and dirty or half dirty machines. These are all little points, but they are of great importance in the effective working of a machine.

(189) The stripping of cylinders and doffers was usually carried out by a wire hand brush, the teeth of which are thrust into the wire spaces and then drawn downwards, so removing the "strips." This is now entirely superseded by the revolving wire brush, such as is shown in Fig. 111, as made by Messrs. John Whiteley and Sons. This is a roller on which is wound card clothing made of hardened and tempered wire. It can be revolved by hand or power, and is carried in the grinding brackets. In stripping it should be set so that the teeth finally penetrate about $\frac{1}{16}$th inch into those on the cylinder, but should

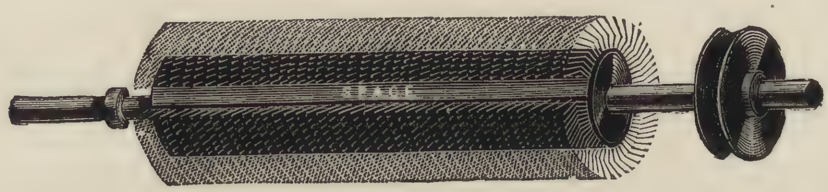


Fig. 111.

be gradually set in to that depth so as to avoid damaging the wire. A speed of 200 revolutions for hardened and tempered, and 150 for mild steel cards is recommended by the makers, the cylinder revolving slowly in the meanwhile. The fleece of strippings thus produced is removed from the roller by dividing it along the narrow uncovered space shown, after which it will lift off by slowly revolving the roller. A similar plan is followed with the doffer. The rollers and clearers are usually stripped by hand, and it is hardly possible to adopt a better plan.

(190) In closing the consideration of the carding engine and its accessories, it is necessary to enforce upon the reader the dictum that good carding is absolutely essential to good work. With it a good even yarn can be made. Without it no such result need be looked for. It is impossible to lay too much stress upon this point, and the care bestowed upon the machine and its clothing will amply repay the spinner. Cleanliness is essential, and it is certain that the want of it often leads to trouble and loss in the subsequent stages of spinning.

CHAPTER VIII.

THE COMBING MACHINE.

(191) The process of combing is only carried out when the finer and better qualities of yarn, such as are used for thread and lace purposes, are spun. The production of these is conducted with greater care than is necessary with the ordinary quality, and it is essential that the short fibres and neps shall be removed. This can only be done to the extent required by a process of combing. It was pointed out in paragraph 23 that in Egyptian cotton a good many short fibres are found, and as the better qualities of yarn are spun from that class of cotton there is a great advantage to be derived from combing. Carding, as was shown, is a continuous process, while combing is an intermittent one, in which small portions of the fibre are dealt with separately and successively. The parallelisation of the fibres is very completely effected, and in addition they are, in a sense, sorted, all below a certain length being removed. It is true that the mechanism can be adjusted to treat fibres of various lengths, within certain limits, but once it is adjusted only the fibres which approximate to the fixed length pass onward through the machine. This procedure results, as will be very readily understood, in the production of a strong thread or yarn, as, in any portion of its length, the number of fibres contained in the cross section will be almost always the same. The nearly complete parallel order given to the fibres has the same effect, and tends to the production of a thread in which exists all the conditions of absolute strength. The combing machine is, with the exception of the mule, the most interesting from a mechanical point of view in the whole range of spinning machines. In the form which is mostly used it was invented by Heilmann, about 1845, and is best known by his name. Although many attempts have been made to construct machines on a different principle, they have not been more than moderately successful, and the Heilmann machine remains to-day the most approved one for the purpose.

(192) The carded slivers intended for use in the combing machine are first treated by a special set of machines, the object of which is to draw the fibres into an approximately parallel condition. It was remarked in paragraph 153 that, although the fibres in the sliver as it left the carding engine were in a more or less crossed condition, they were so openly laid that a slight endwise pull would draw them into a practically parallel order. In spinning ordinary yarns this is done by the drawing frames, which are described in the next chapter. Although the sliver eventually delivered from the combing machine is also drawn, it has been found desirable to commence this action before combing commences, and the result is that a sliver is produced which is exceptionally even and strong. The exact operation of drawing will not at this juncture be described, as it will be necessary to go over the same ground at a later stage.

(193) The first machine by which the slivers are treated is known as the Sliver Lap Machine, and as made by Messrs. Dobson and Barlow, is shown in perspective in Fig. 112. It consists essentially of drawing rollers, to the action of which the slivers are fed from the cans. From 12 to 16 slivers are treated at one time, and on their way from the guide plate to the rollers, they pass over the spoons formed at the ends of detector levers, this part of the mechanism being clearly shown. The failure of any one of the slivers causes the machine to be stopped as in the drawing frame, so that any unevenness in the lap is avoided. The slivers in passing the drawing rollers are laid side by side, and are in this way flattened, so that when they are delivered by the rollers, they have assumed the form of a ribbon, which is rolled up into a lap, by means of a specially driven roller. This treatment straightens the fibres, and prepares them for further treatment.

(194) This is given on the Ribbon Lap Machine, which is illustrated in Fig. 113. The laps obtained in previous machines are to the number of six, placed behind the drawing rollers in the machine. Four lines of rollers are provided, as in the drawing machine, and the laps are thus reduced in thickness until they become like a thin ribbon. By this time the various fibres of cotton are pulled into parallel order, and are in a good condition for combing. They are respectively guided round the curved plates shown, and are laid flat upon

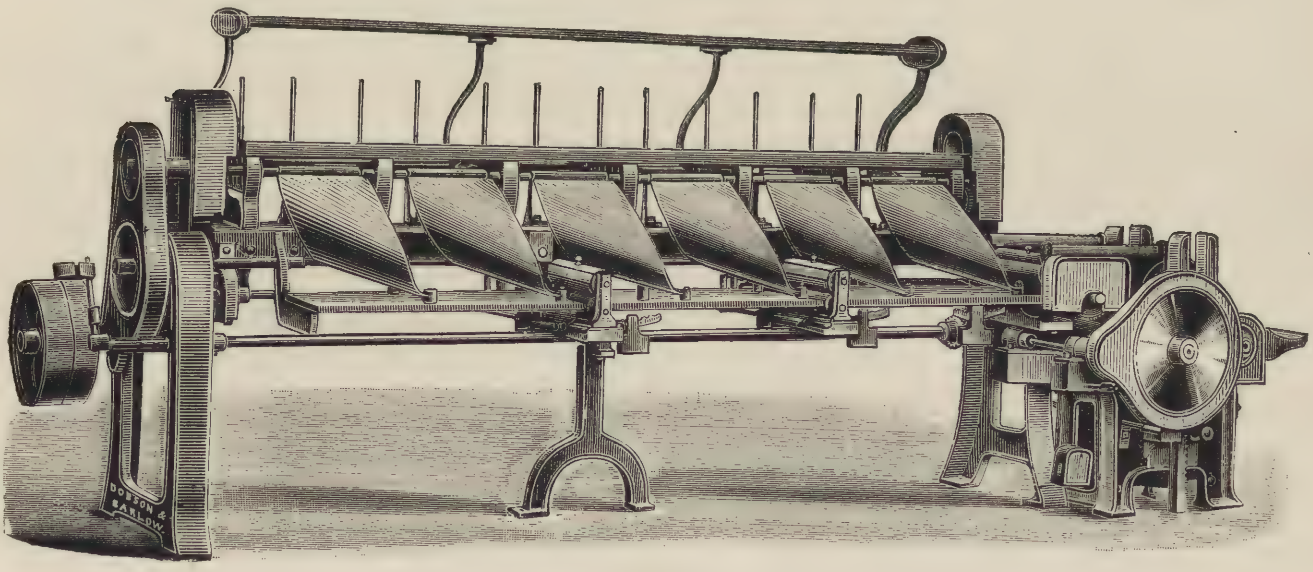


Fig. 113.

a highly polished iron plate. The lap which is delivered at the end of the machine furthest from the driving head is laid upon the plate first, and all the others are subsequently imposed upon it. The combined six laps are then passed through a pair of calender rollers at the end of the machine, by which they are compressed, and the combined lap is subsequently wound into rolls of $7\frac{1}{2}$ or $8\frac{1}{2}$ inches wide. These rolls or laps are fed to the combing machine. The chief advantages of this arrangement are those arising from the

parallel order of the fibres. These are evenly laid in an uncrossed state, and there is consequently little danger of any rupture of them by the comb teeth. Further, the latter are not strained in the effort to disentangle the fibres, and a fruitful source of breakage is thus avoided. There is another point, to which special reference was made in Chapter V., namely, the equalisation of the thickness arising from the imposition of the laps upon each other.

(195) The lap being produced is placed upon two rollers, A A^1, as shown in Fig. 114, which is a transverse section through one head of a Heilmann machine, as made by Messrs. John Hetherington and Sons. Enlarged views of portions of the mechanism are shown in Figs. 115 and 116. A combing machine is usually constructed with from six to eight heads, the driving mechanism for all of which is placed at one

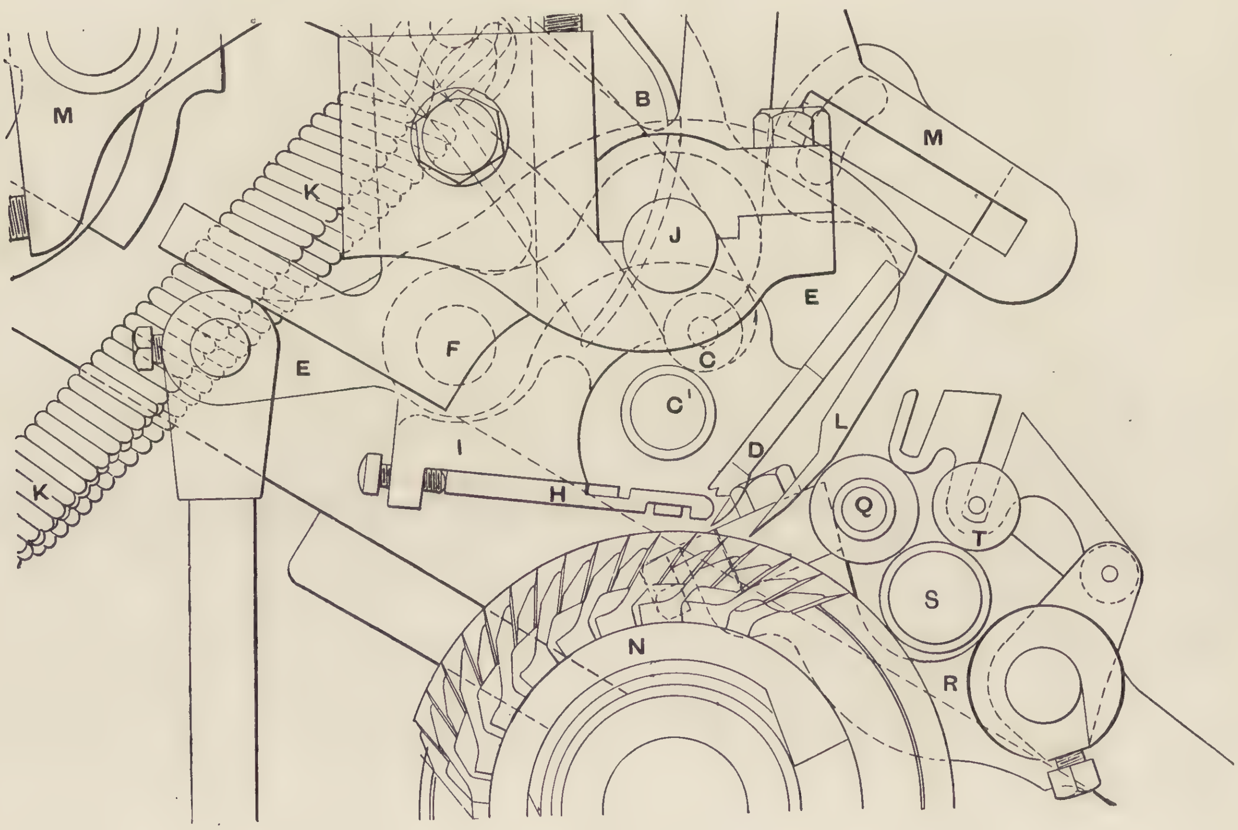


Fig. 115.

end of the machine. The lap rollers A A^1 are positively rotated at a speed corresponding to that of the passage of the cotton through the machine. The lap as it is unrolled is carried along the trough B, made of its full width, the lower end of which terminates a little distance from the feed rollers C C^1. The bottom rollers of each head are suitably carried on brackets fixed to the roller beam, being made of steel, and a little longer than the width of the lap. They are fluted longitudinally, and drive the top rollers by

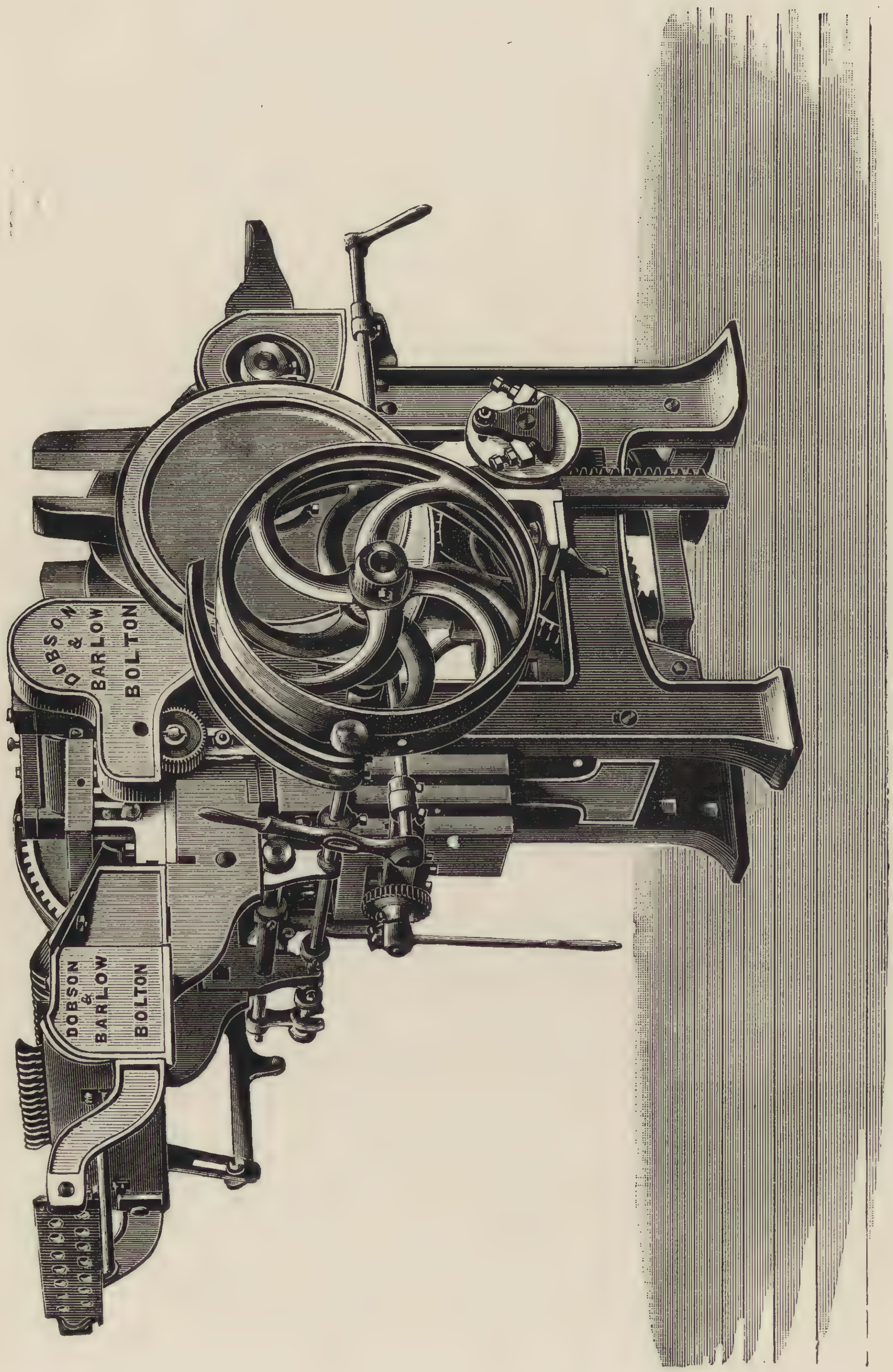


Fig. 112.

frictional contact. The top rollers are also made of steel, being plainly cylindrical and covered with a sheath of cloth and leather, but a porcupine roller is often used instead of a pair of rollers. This, it is contended, opens the lap and decreases the waste. They are weighted by means of hooks on their axes, to which springs are attached. Immediately in front of the rollers the nipper is placed. This consists of two jaws, the upper one, D, being fastened to the lever E, which oscillates on the short shaft F, receiving its motion from a cam at the driving end of the machine through a shaft, short lever, and the connecting rod G. The lower jaw, H, is also made of steel, being rounded at its outer edge and covered with smooth leather. As the upper jaw is peculiarly fluted, as shown, the contact of the two establishes a nip of the cotton at the points of the

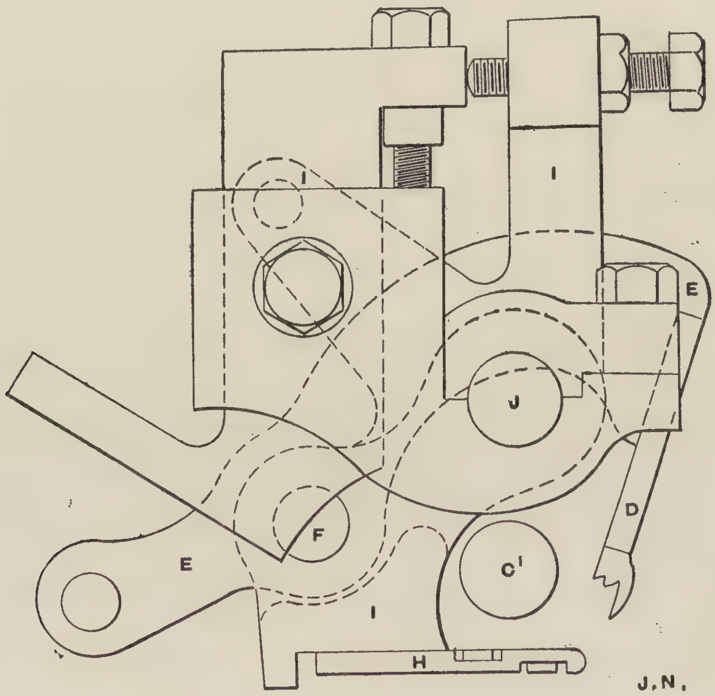


FIG. 116.

flutes. The lower nipper blade, H, is fixed to two levers, I, which rock upon the shaft J. The spiral springs, K, are attached to the tail ends of the levers, I, and ordinarily keep the lower jaw in the position shown in Fig. 116, but also permit of it making a slight receding motion when pressed by the upper jaw after the nip is created.

(196) The foregoing portion of the machine constitutes what may be called the feed part, there being three distinct operations in the process—feeding, combing, and detaching. In front of the nipper the top comb, L, is fixed, being attached to the lever M in such a way that the necessary adjustment can be made. Below the nippers the comb cylinder N is placed, being constructed with a barrel or "comb stock," to which

is attached the comb needles. Of these there are seventeen rows, fixed in a metallic bed, or piece, known as the "half lap." These should be accurately shaped, so as to be readily renewed or replaced when required, and are fastened to the comb stock by screws. The width of each row of combs is a little greater than that of the lap, and each row is parallel to the others. The needles are set at different pitches, beginning with one of $\frac{1}{30}$th inch in the first row and terminating with one of $\frac{1}{90}$th inch in the last. On the opposite side of the barrel a segment N^1 is fixed, which is fluted longitudinally. A circular brush, O, is fixed so as to clear the needles as they revolve, and can be easily set up so as always to be in touch with the combs. This brush revolves between the comb stock and the doffing cylinder P, and running at a higher velocity than the latter, it removes the waste taken from the cylinder and transfers it to the doffer, which is clothed with a metallic brush surface. An oscillating comb removes the waste from the doffer and beats it into a receptacle formed to receive it.

(197) The detaching portion of the mechanism consists of the three rollers Q S and T, but the fluted segment N^1 also aids in this portion of the work. The roller S is known as the "steel detaching" roller, and receives an intermittent motion in both directions from a cam at the end of the machine. The roller Q is known as the "top detaching" or the "leather" roller, and is covered with leather, being borne by levers R' to which the necessary oscillation is given by a cam and the connecting rod R^1. The heads of the levers R are arranged with a block and setting screw, by which the period of contact of the roller Q and segment N^1 is regulated. The movement of Q is round the detaching roller towards the comb cylinder until it comes in contact with the fluted segment N^1, after which it is again returned to its original position. The top roller T is made brass-covered, having longitudinal flutes, and is of sufficient weight to nip the sliver firmly. It, of course, receives its rotary motion from the detaching roller, and is carried in a lever known as the "horse tail." After passing the rollers S T the combed sliver is carried along a trough through a trumpet-shaped guide to the calender rolls U V, which deliver it on to a highly-polished plate. It is thus guided to a draw box at the front of the machine, in which are drawing rollers, and is then passed into a coiler, as in the carding engine, being delivered into similar cans.

(198) Having thus described the mechanism employed, its method of action can now be explained. The lap, being passed to the feed rollers, is delivered by them intermittently in short lengths corresponding to that of the staple. This intermittent rotation is obtained by the use of a star wheel, which is revolved by a train of gearing from the cylinder shaft. The extent of the forward movement is regulated by the length of the fibre, the roller making such a portion of a revolution as causes its surface to move that distance, usually from $\frac{1}{8}$th to $\frac{1}{10}$th of a revolution. The roller being one inch diameter, the relative distance its surface would travel, and the length of fibre delivered in each case, would be ·39 or ·31 inch. The nipper jaw D, while this movement is being made, is open, and the top comb L is dropped. As soon as the rotation of the feed rollers ceases the nipper closes and grips the fibre. The downward movement of the top nipper blade D is, however, continued beyond that point, and the lower jaw H receives a further downward movement which puts the helical springs K into tension. In the ordinary position of the nippers the comb needles in

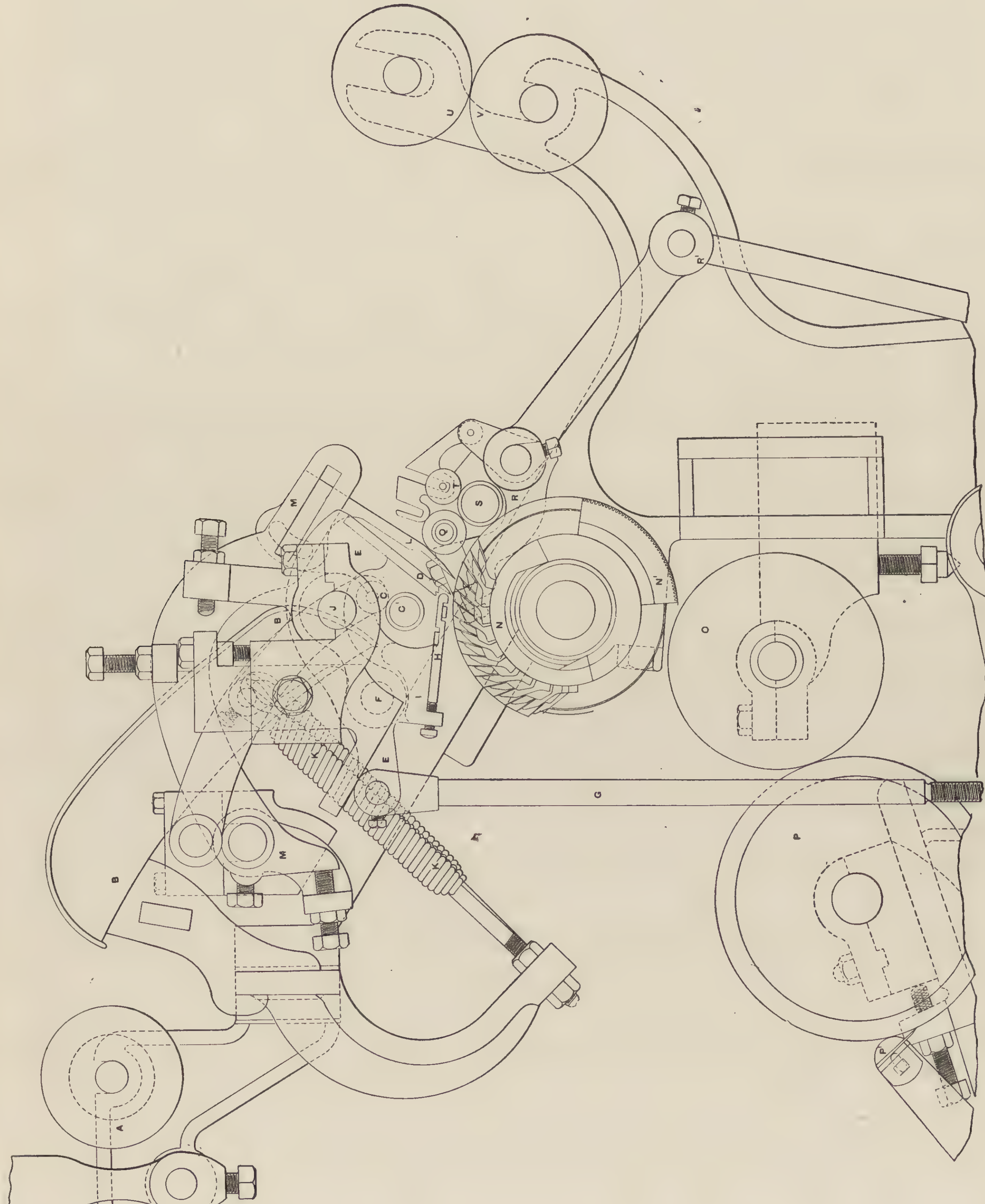


Fig. 114.

their revolution would pass the cotton, but the recession of the nipper, as described, brings the uncombed end of the lap into the path of the needles, which accordingly pass through and comb it. It may be here explained that after the process of combing the combed and uncombed parts of the lap are separated, and that, after the free end of the latter is combed, a small portion is pulled away from it, and joined to the previously combed portion in the manner about to be described. For convenience it will be as well to refer to the uncombed cotton as the lap, and to the combed cotton as the sliver.

(199) The circular combs having passed, the continued revolution of the nipper cam allows the nipper to again move forward, and to carry the combed end of the lap into a position in which it can be dealt with by the fluted segment N^1. The top comb L drops into the lap at a point in advance of the uncombed portion, and the leather roller Q at the same time is moved round the detaching roller S. As the fluted segment N^1 comes under the cotton the leather roller engages with it, and the continued revolution of the former causes the two to act as a sort of revolving nipper. The nipper D has been previously opened and a tuft of cotton is drawn away from the lap, partially by the action of the segment and leather roller. To the latter a peculiar motion is given by a cam, which acts through special mechanism. It is not enough that the combed tuft should be detached from the lap, but it must also be attached to the sliver. In order to effect this the detaching roller moves backward to the amount of one-third of a revolution, previously to the engagement of Q with N^1. This, of course, carries a corresponding length of the sliver with it, and lays the free end of the combed tuft on to the free end of the sliver, to which it is at once attached by the pressure of the leather roller Q. The backward motion of the detaching roller commences after the combs have passed through the lap end, before which it is stationary. The piecing being complete, the segment N^1 and leather roller Q recede from each other, and the detaching roller makes a forward movement of two-thirds of a revolution. This results in the complete attachment of a tuft of cotton, the uncombed part of which is drawn through the top comb, this preventing the passage of short fibres and nep, which are retained in the lap, and removed by the next passage of the rotating combs. The attachment having been accomplished the detaching roller becomes stationary, the top comb is raised, a fresh portion of lap is fed, and the process is recommenced.

(200) There are thus three distinct stages in combing, viz., the feeding, combing, and detaching, and in the course of the operation the tuft of cotton is completely separated from the lap, and joined to the sliver. It is, of course, absolutely necessary in a machine the movements of which are so delicate, to establish and maintain a very accurate setting. For this reason ample provision is made by which the adjustment of the various parts can be accurately effected, as a reference to Fig. 114 will show. Although the motion given by the cams is of necessity a positive one, and its range fixed to suit the material, the timing of the movements of the different portions of the mechanism is secured by the facilities named. The full importance of this power will be appreciated when it it is stated that from 80 to 95 "nips" or beats are made per minute. Without the most delicate setting it would be impossible to ensure successful work, and this explains the reason for the many adjusting screws shown in Fig. 114.

(201) In treating of the carding engine it was explained that the production of an even sliver was of high importance. This is equally so in the cómbing machine. It has been explained that the cotton is held by the nipper jaws, while the projecting end of the lap is combed, and it will be readily understood that this action will tend to widen or flatten it a little. This result is also produced by the action of the feed and detaching rollers. Thus a sliver is produced with uneven edges, which is very undesirable. In order to remedy this, Messrs. John Hetherington and Sons have adopted the device which is shown in front elevation and section in Figs. 117 and 118. In this case the lower nipper jaw, or cushion plate A, has attached to it at each side a guide plate, which has two projecting pieces C D, one at the front and the other at the back of the nipper. D is curved so as to allow the jaw B to descend

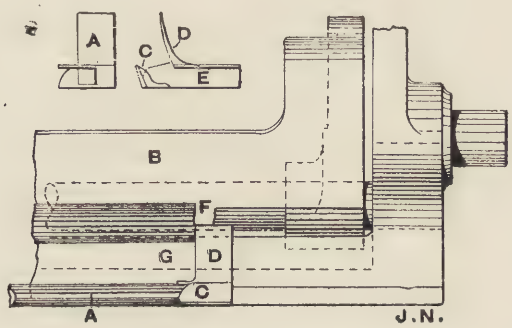


FIG. 117.

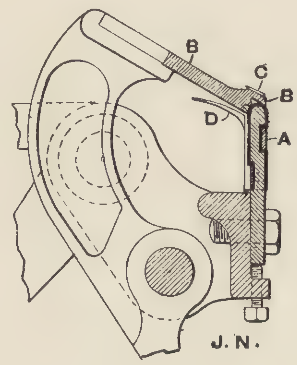


FIG. 118.

without difficulty. The two guiding portions C and D are coupled by a connecting piece E so as to form one casting. The nipper plate is cut away, as shown at F, to clear the front guide, which is arranged so as to be in contact with the front edge of the cushion plate A. By this arrangement it is practically impossible for the fibres to escape sideways as the lap is nipped. The length of the nipper plate is sufficient to hold all the fibres firmly, thus ensuring their perfect combing. The fibres are prevented from lifting during the descent of the nipper by a small projecting piece and by the back guide D. The cylinder is also formed with a flange to obviate spreading. By these arrangements a wider lap can be used than would otherwise be the case, and the amount of cotton passed is therefore greater. In addition to this the selvedge is much more even, and the sliver produced in better condition for drawing.

(202) In Fig. 119 a perspective view, and in Fig. 120 a sectional view is given of Messrs. Dobson and Barlow's Heilmann combing machine. In the main it is similar to the machine previously described, but there are some alterations in detail which require explanation. One of these is shown in elevation and plan in Figs. 121 and 122, and is an improvement in the mode of working the detaching rollers, which it was shown have to revolve a little distance in each direction alternately. This motion is placed at the end of the machine, and consists of a large cam F, which is suitably driven and with which a bowl fastened in

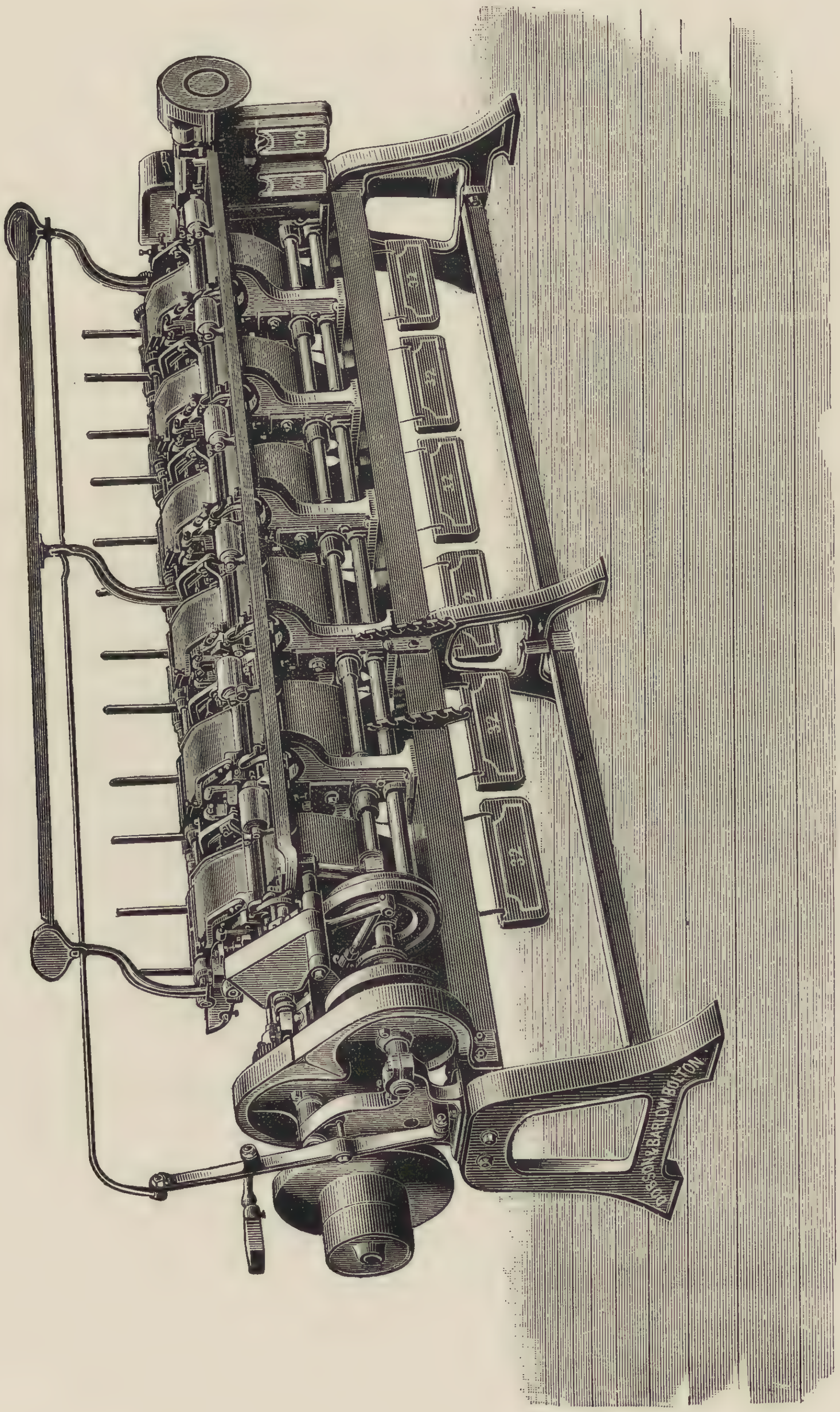
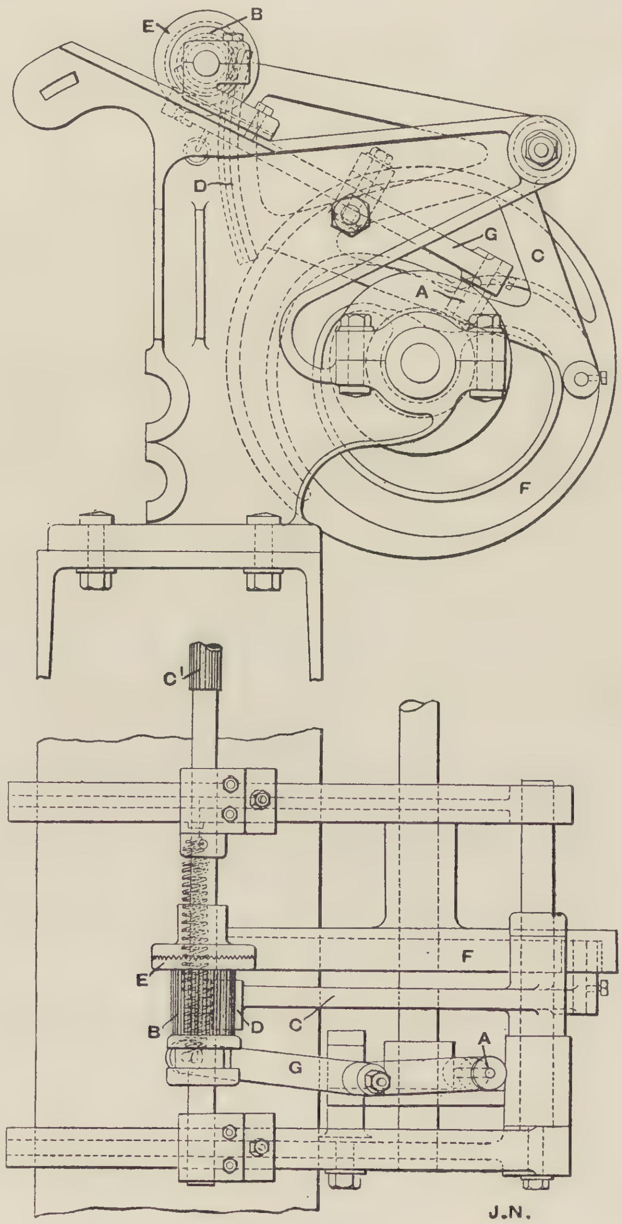


Fig. 119.

quadrant C engages. C is formed on its outer edge with a toothed rack, which engages with the pinion B, loose and sliding upon the spindle of the detaching roller C^1. B is part of a toothed clutch, as shown at E, and has a ring groove formed on its boss, with which a claw at the end of the lever G engages. The sliding



FIGS. 121 AND 122.

half of the clutch is usually drawn inwards by the spiral spring shown in the plan, so that the normal tendency of the two parts is to engage. At the end of the lever G a pin carrying a bowl is fastened, the latter being constantly in contact with a cam surface fixed on the shaft on which the cam F is secured.

The action of this mechanism is easily understood. The cam surface which actuates the lever G at the moment when the detachment of the tuft of cotton is completed, allows the clutch to become engaged. Simultaneously with this the cam F causes the quadrant to make its stroke, and thus rotate the detaching roller C^1 as much as is required when the lever G is moved, so as to disengage the clutch, and the detaching roller is free to revolve. The advantage of this motion is principally its simplicity, which causes it to be easily worked at a high speed without endangering its positive action. It can readily be adjusted to suit different staples of cotton, without any change pieces.

(203) Referring now more particularly to Fig. 120, it will be noticed that a change is made in the construction of the nippers. In the machine as usually constructed, the lower blade H is used as a cushion, being covered with leather, an operation which is a somewhat delicate and difficult one. In Messrs. Dobson's

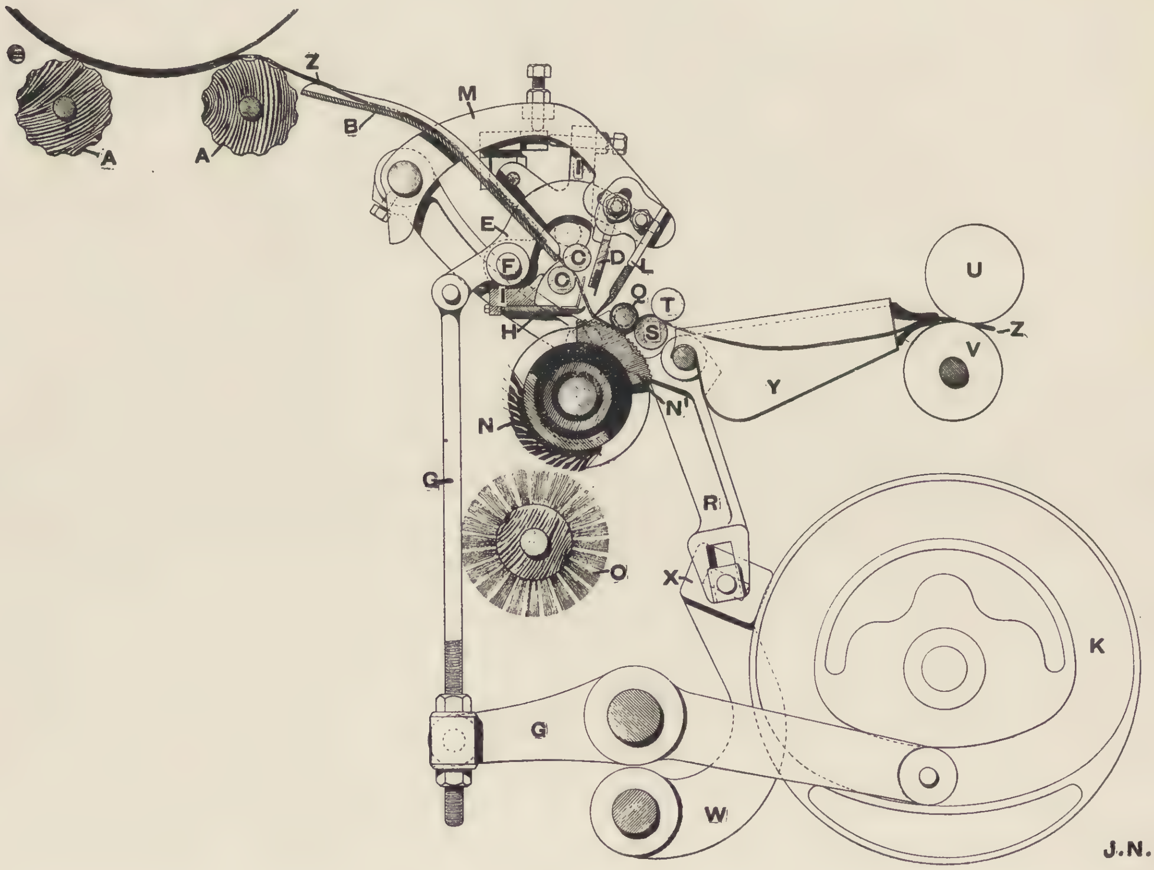


Fig. 120.

machine the lower nipper blade H is made a somewhat blunt V shape, while the upper blade or knife D is fitted with a narrow strip of india-rubber or leather. The nip is obtained between these surfaces, and owing to the yielding nature of the strip, an efficient grip is always established. As a corollary of this the lower nipper

blade D is fixed, and does not yield as in the ordinary mode of construction. The cam for working the nipper is shown at K, and its motion is communicated through the lever and rod G. Its shape is such that it works easily and smoothly without any difficulty, at a speed of from 80 to 95 nips per minute.

(204) In order to avoid misapprehension, it may be as well to say at this point that the mechanism employed being similar to that in the ordinary machine, the various parts are all marked with the same reference letters in each case. The cotton is marked Z and its passage through the machine can be clearly followed. This will avoid any special reference to the mechanism common to both machines. The leather roller Q is in this case carried at the ends of two levers R, which are coupled directly to the lever W, which receives the necessary reciprocal motion, and the joint X at the end of W is so arranged, that it can be very readily set. The setting is very easily made, and as the operation of the "leather" or "piecing" roller is one of the most delicate in the machine, any means by which this can be more readily adjusted is of importance. The top roller T is made of a large size, so as to press well down upon the detaching roller, and not to vibrate, however high the speed of the machine may be. A minor improvement is made by arranging that as the bristles of the cleaning brush wear, they can be driven at a quicker speed.

(205) Although the Heilmann machine has been in use for about 40 years, it is a singular fact that no other machine for the same purpose has had anything like the same success. A machine, invented by Mons. Imbs, has been used to a certain extent on the Continent, but it has not been adopted except in a small percentage of the cases in which the Heilmann has been used. A machine, which is extremely ingenious in its mechanism, and which has been a little used for short stapled cotton, is the joint invention of Messrs. Pinel, Lecœur, and Hetherington. In this machine the principle of a revolving nipper is adopted. A long pipe forms the main moving piece of the machine, and is of sufficient length to constitute six heads, its circumference being divided into three parts. For each head three longitudinal slots are cut in the pipe equal in length to the width of the lap. Three sets of nippers are fitted to each head, the fixed jaw of each coming up to the edge of the slot, which, when the nipper is closed, is covered by the loose jaw. When the nipper is open the slot is exposed. Between each pair of nippers is placed a comb segment with thirteen rows of needles. A feed nipper presents the end of the lap to the needles, the pipe then revolving at its highest speed. When the end of the lap has been combed the revolving nipper comes opposite the feed nipper, which is stationary, and the pipe revolves at a slower speed to allow the combed end of the lap to be drawn into the nipper. This is effected by the suction of an air current induced by a fan connected to the tube. This operation being completed, the revolving nipper closes on the lap and the feed nipper allows a short length of lap to be taken through. The separation of the tuft is then made, and its other end is combed by being drawn through a top comb as in the Heilmann. The pipe then continues to revolve, and while the next in the series of nippers is taking its feed, the one holding the combed tuft opens slightly on arriving at a table placed at the front of the machine. By the aid of a pusher the fibres are superposed on those already on the table, a continuous fleece being thus made which is taken forward by two pairs of draw rollers. The sliver is made exactly as in the Heilmann. The Lecœur machine is not suitable for long stapled cotton, but it will comb very effectively the short Indian and American staples. Of these it will produce 400lbs.

per week, with a per centage of waste of from 16 to 20. It is only in special cases that the combing of this class of cotton is remunerative.

(206) The waste from the combs, which varies from 15 to 17 per cent, is carried away by the brush, which in turn is stripped by a comb, and the strippings fall upon a lattice. By this they are carried to a calender roll and made into a lap which, as it contains fibres of good quality, but of insufficient length for the ordinary combed yarns, is used up in the manufacture of coarser qualities. The waste from the combing machine being considerable, its utilisation is important.

CHAPTER IX.

THE DRAWING MACHINE.

(207) The slivers produced on the carding engine, although, as previously noted, composed of approximately parallel fibres, are not perfectly laid in that way. If, however, they are subjected to a pull in a longitudinal direction they easily assume the parallel position. Even slivers produced on a combing machine, in which the fibres are, as has been observed, in much better order than when treated in a carding engine, are improved by being subjected to this drawing action. The net result of the process is an improvement in the strength of the resultant thread. Not only is it essential to improve the parallelisation of the fibres in the sliver, but it is equally desirable to produce a sliver of even weight and thickness. As it leaves the carding or combing machine the sliver is not so regular in weight as is requisite, and if this irregularity were allowed to go uncorrected a yarn of varying thickness would eventually be spun. It is true that the variations are not serious in amount, but they are of sufficient importance to render it desirable to correct them. Again, it is necessary to reduce these irregularities in order to facilitate future manipulation, and, generally speaking, the proper conduct of the drawing process is of prime importance to successful spinning.

(208) The essential feature in a drawing machine or frame is, of course, the mechanism by which the extension or drawing of the sliver is effected. As it is necessary to pass the material continuously through the machine while reducing it to parallel order, the use of rollers becomes imperative. These are arranged in pairs, one above the other, and there are four pairs arranged in parallel lines with each other, as shown in Fig. 124. That illustration is a transverse section of the drawing frame as made by Mr. S. Brooks, Figs. 123 and 125 being respectively end and front views of the same machine. The lower rollers are borne, as shown, by brackets B fastened to a longitudinal beam C, known as the "roller beam." They are made in sections and are coupled throughout the length of the frame, so as to form four continuous "lines," which are driven from one end of the machine. Each set of four lower and four upper rollers constitutes a "head," and there are usually from two to four heads in a machine. The lower rollers are made of a special class of wrought iron, very fine and clear in the grain, and are accurately turned throughout, being formed with two or three bosses to each head. They are also fluted with fine flutes in a longitudinal direction, great care being taken to ensure the flutes being smooth and quite free from anything likely to catch the cotton. The upper rollers are made of cast-iron, and are placed on the top of the lower lines, against which they are constantly pressed by means of the hooks D and weights E, the former passing over the arbors of the rollers. The arbors of the top rollers engage with grooves in the roller brackets, and the rollers are thus prevented from moving laterally, although they have freedom of vertical movement. Bars forming caps

for the arbors of the top rollers are fitted, being known as "cap bars." It is the practice to form the top rollers with as many bosses as there are on the bottom rollers in each head, and of a length corresponding to that of the latter. Thus if, in each head, the bottom rollers had three bosses the top rollers would be formed to correspond, and the slivers to be drawn would be passed between them. In this case the head would be said to be one of three "deliveries," and a machine is usually described as being one of so many heads of a certain number of deliveries. It will be easily understood that the top rollers are not positively driven, but derive their motion by frictional surface contact with the lower set. The top rollers are accurately turned, and are usually covered with a specially-prepared soft leather, formed into a sheath, which can be drawn

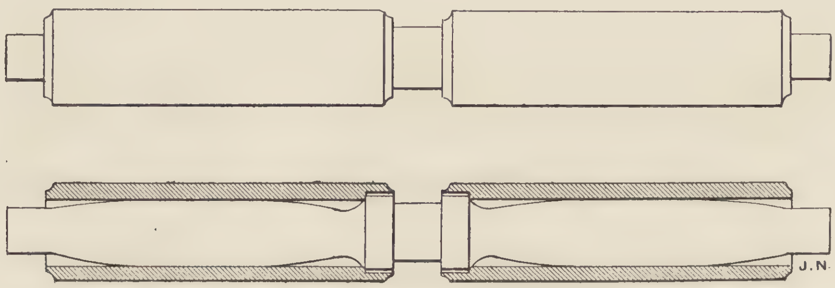
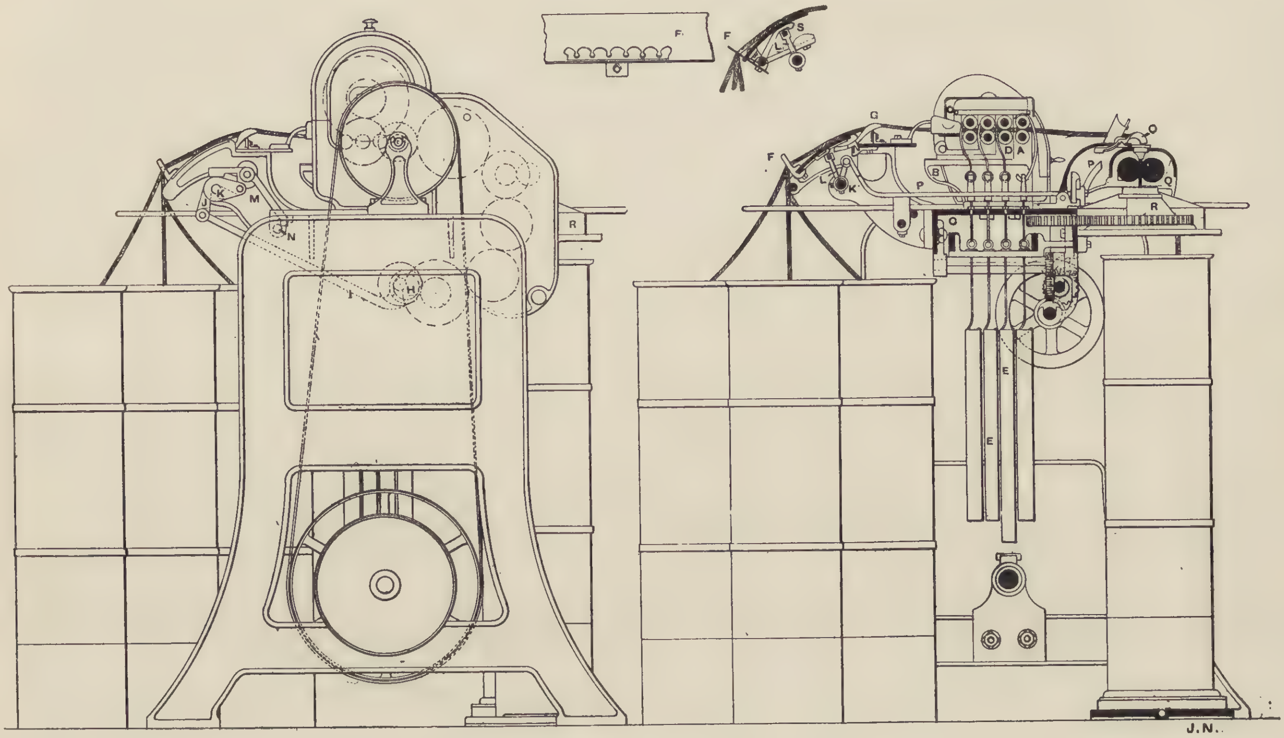


FIG. 126.

over the boss of the roller. Special care is taken in forming these coverings, so that they have no extra thickness at their joints, and, after they are drawn on to the rollers, the latter are subjected to a rolling and pressing action, which beds the leather firmly and ensures the roundness of the roller. The mode of preparing the rollers will be described in full in Chapter XIV. It is now almost the universal practice to use the loose boss top roller invented by the late Mr. Evan Leigh, and illustrated in Fig. 126 in longitudinal section and elevation. Its advantages are many, and arise from the lessened friction consequent upon the more perfect lubrication, which is also obtained with a smaller quantity of oil.

(209) The rollers are driven from the end of the machine in the way shown in Fig. 123 in end elevation. They may be arranged with all their driving wheels at one end of the frame, or may be—as is the case in Messrs. Howard and Bullough's machine—driven at both ends. That is to say, the driving of the first and fourth rollers may be effected at the gearing end of the machine, while that of the intermediate lines is obtained at the other end. It will be, perhaps, as well to say that the first line here means the back rollers, and the fourth the front. Whatever be the system of driving adopted, the front roller is always the primarily driven one, and for this course there are good reasons. The thickness of the emerging sliver is determined by the relatively superior speed of the front roller, which runs at a faster rate than any of the others. Thus it becomes an easy matter to reduce the speed of the remaining rollers, and this course is preferable to using a slow running wheel as the driver from which higher velocities are to be obtained.



FIGS. 123 AND 124.

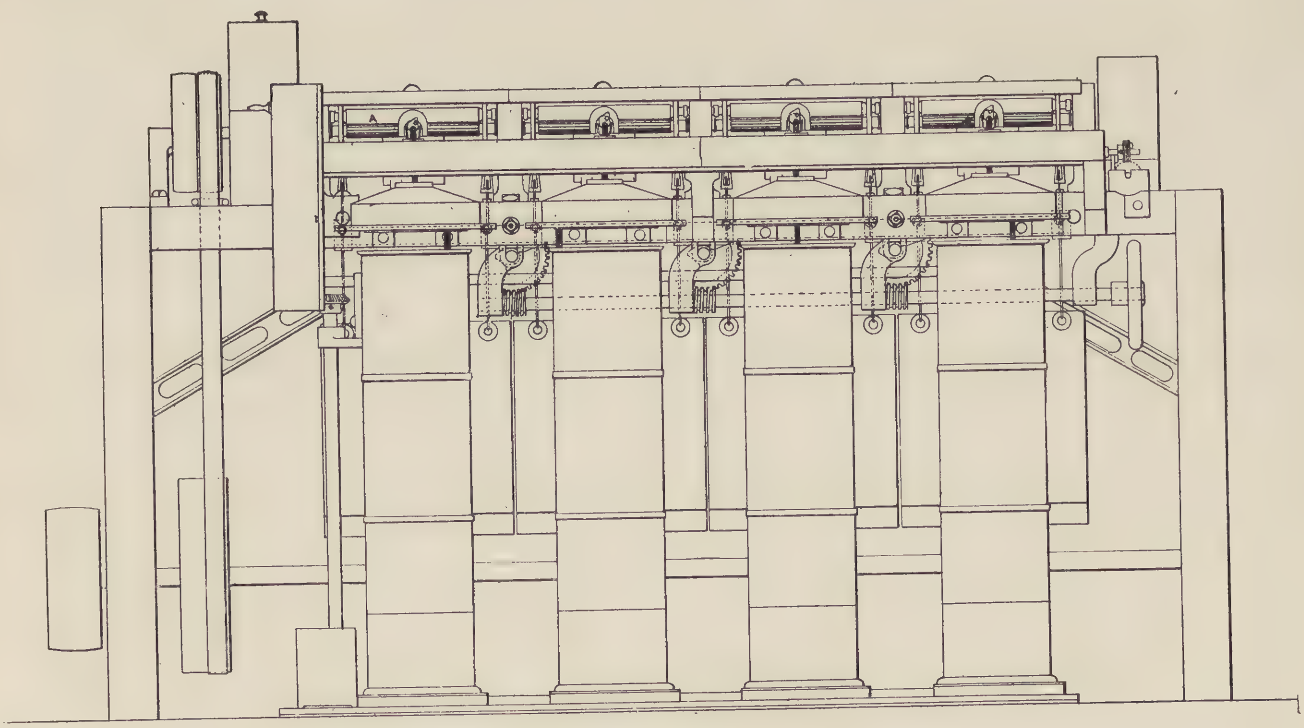


FIG. 125.

Between the driver and driven roller a series of wheels are interposed, which are used as change wheels, so as to allow of an easy adjustment of the relative speeds of the whole series.

(210) The proper construction of a drawing frame turns largely upon the consideration of a number of small points. In this, as in all other machines used in the preparation of cotton, due regard must be had to the material which is being treated. Especially is this the case in drawing. The "staple" here plays an important part. If the distance between the centres of each line of rollers exceeds that of the length of the "staple" it is quite clear that no drawing worthy of the name will take place. To draw anything one end of it must be firmly held, and if the fibres could lie between two pairs of rollers without being gripped by either it is obvious they would not be drawn. Thus the distance between the centres of the rollers must be regulated to suit the material being treated, and the roller bearings are arranged to permit of that adjustment. This leads to the necessity, where very short slivers are drawn, for the reduction of the diameter of the rollers so as to permit of their being set in together more closely than could otherwise be done. Thus East Indian cotton is best dealt with by rollers of a small diameter set closely; while Sea Island or Egyptian can be drawn by larger rollers set wider apart. The principle underlying this practice has been indicated, but may be formally stated. The necessity exists for the fibre being drawn to be held at one end by one roller, while it is subjected at the other to the pull of a faster running roller. It is therefore essential that the distance between the centres of the rollers shall be such that the fibres are sufficiently drawn without being subjected to overstrain, by which a liability to rupture is incurred.

(211) It is the universal practice to effect the major part of the drawing between the third and fourth rollers, the increase in speed prior to that having been comparatively small. The exact speeds at which the various lines run depend largely upon the material treated, but a common acceleration is as follows: Assuming the first or back roller to revolve at 100 times per minute, the second line would run at 125, the third at 175, and the fourth at 275. The attenuation of the sliver between the first and second line is only 25 per cent; that between the second and third 40 per cent; and between the third and fourth 57 per cent. Putting it in another way, assuming one foot of sliver to have passed through the back rollers, it would become 15 inches long after passing the second roller; 21 inches as it leaves the third roller; and 33 inches as it finally emerges from the front roller. Thus, although the *percentage* of increase between the third and fourth is not largely in excess of that arising between the second and third rollers, the actual increase is exactly twice as much. These proportions are approximations to those which are actually employed, but, as was said, much depends on the character of the material which is being treated. In dealing with a soft elastic fibre like Sea Island cotton, light weighting and an easy draught is possible, while, if a harsh strong fibre is subjected to the same treatment there would be little effect produced. It is therefore necessary to put additional weight upon the rollers and thus increase their grip. A severe treatment of this character, which would be fatal to a weak or fine cotton, is beneficial to the coarser varieties, which can easily be subjected to a coarser draught. All these are points which require attention in practice, and careful observation will do more than many instructions in giving the knowledge of the right course to pursue.

(212) Another point requiring close attention is the preservation of absolute cleanliness. All cotton in its passage through the machines used, gives off a certain quantity of loose, short fibre, to which the name of "fly" is given. This is found all over the machine, and it adheres to the rollers in considerable quantity. Unless it is removed in some way it is apt to collect into thick pieces, or "slubs," which attach themselves to the sliver, and thus cause thick places. These, of course, are perpetuated in every subsequent stage, and the removal of the fly, therefore, becomes of great importance. To accomplish this desirable end appliances known as "clearers" are fitted. These are flannel-covered surfaces, either flat or cylindrical, which rest upon the rollers. One common form is a plain, wooden cylinder covered with rough flannel, which is placed upon, and rests between, two of the lines of rollers, the rotation of which causes it to revolve. The rougher surface of the flannel licks up the fly from the rollers, and a periodical stripping is sufficient to keep the clearer effective. A simpler and also a common arrangement consists of a strip of flannel stretched within a cover and resting on the whole of the top rollers. A third modification is known as "Ermen's revolving clearer," and is an endless band of flannel passed over two rollers fixed in the cover. The lower part of the band rests upon the top rollers, and the clearer is slowly traversed, so as to remove the fly and convey it to the upper part of the case when the band is turned up. Here an oscillating comb is placed, and scrapes up the fly into small rolls, which can easily be removed periodically. A further form of clearer is made by Messrs. Dobson and Barlow. It consists of two wooden rollers sustained in a frame which is hinged at one end. One of the rollers which presses upon the back rollers is suitably driven so as to take up the fly from the first and second pair. The other roller is loose upon its spindle, which is much smaller than the bore of the roller, so that the revolution of the front rollers causes it to rotate at a speed somewhat below that of the rollers. Both of the wood cylinders are covered with flannel, and thus take up the fly with very great ease. It was found by practice that the positive driving of the back clearer effectually cleaned the first two sets of rollers, while a similar procedure with the front clearer did not lead to the same result. By allowing the latter to be frictionally driven, the rollers can be kept clean without difficulty. To strip the clearers they only require raising, when the fly can be readily removed.

(213) A reference to Figs. 123 and 125 will show that extending along the frame is a shaft having a hand-wheel at the end, and a number of worms keyed on it. The latter gear into worm wheels, on the axes of which cams are fixed by which a bar—through which the weight-rods pass—is lifted. As the rods have a loop at their upper end which cannot pass through the holes in the bar, it is clear that the elevation of the latter will also raise the weights. In this way the pressure on the rollers is relieved. This is of value when the frame is stopped for any prolonged period, as the maintenance of the pressure during that time results in the formation of flat places on the rollers, which are detrimental to good work. It is undesirable to put on or take off the weight suddenly, and some makers prefer to use a simple lifting appliance by which each weight can be released singly.

(214) The important features in connection with the roller portion of the mechanism are—first, their perfect finish; second, the adoption of such diameters and distances as are suitable for different lengths of

staples; third, their effectual cleansing; and, fourth, the regulation of their velocity so as to suit the material being dealt with.

(215) It was pointed out in paragraph 207 that there are certain irregularities in the size of the slivers, as obtained from the carding engine. Up to the present the machine has been considered as though each sliver was treated separately, a course which would result in the delivery of a sliver longer than, but possessing the same defects as, the original one. That this must be so is apparent, unless some provision is made for the acceleration of the speed of delivery when a thin place was passing, or its retardation when a thick place occurred. It therefore becomes necessary to find a method of rectifying these defects, and it is obtained by passing several slivers through the machine simultaneously. Reference is now more particularly made to Fig. 123, which shows the mode pursued clearly. A number of full cans from the carding engine—up to eight—are placed behind each delivery, and the slivers they contain are combined and passed through the rollers together. Before passing on to consider the exact effect of this arrangement, a few words may be said as to the method of feeding the cans to the machine. As each can contains approximately the same length, it follows that, the rate of passage being the same throughout the machine, they would all become empty at practically the same time. This implies the necessity for the attendant to remove the cans and piece up the new slivers all along the frame almost simultaneously. This is practically impossible, and it is therefore highly desirable that there should be an arrangement adopted which would enable the cans to be substituted at different times along the frame. In a little but valuable work, "Progress in Cotton Carding," the late Mr. F. A. Leigh, of Boston, U.S.A., makes the following remarks: "If there are 10 pounds (or 1,000 yards), say, in a full can, instead of putting them all up full at first, it is better to put them up at back of drawing in four sections, say:—

$$\frac{\text{4 or 6 cans}}{2\tfrac{1}{2}\text{lbs.}} \qquad \frac{\text{4 or 6 cans}}{\text{5lbs.}} \qquad \frac{\text{4 or 6 cans}}{7\tfrac{1}{2}\text{lbs.}} \qquad \frac{\text{4 or 6 cans}}{\text{10lbs.}}$$

After that replace with the full 10 pounds (or the 1,000 yard) cans, and they will continue to empty in rotation, all full cans having the same length. The tender [minder] will know exactly where to find them."

(216) The diminution of the irregularities in the slivers is most important. The plan pursued is to pass several slivers through the same set of rollers, and deliver the combined sliver at the front of the machine. The number of slivers which are combined varies considerably according to the practice of different spinners, but is not more than eight. Now, if it be assumed that an irregularity of 40 per cent existed in one sliver, and that it was drawn simultaneously with five others in which that irregularity did not exist, the latter would be reduced to one-sixth, or $6\frac{2}{3}$ per cent. It is, however, the custom to "put up," or feed, the slivers so obtained to another head of the machine, and subject several of them to a second or even a third drawing. Assume, therefore, that four of the partially drawn slivers were fed and again drawn. The irregularity would be reduced to $1\frac{2}{3}$ per cent, and a further drawing would again reduce it. The figures given are hypothetical, and it is not likely, of course, that only one sliver would be irregular in thickness, but the example serves to show the principle. The number of "doublings" given to the sliver is arrived at

by multiplying the number of ends passed through at each drawing. Thus, in the case stated, the doublings are $6 \times 4 \times 4 = 96$, and it can be easily seen that any difference in substance which existed at first would be very speedily rectified, and would not be of much moment by the time the finished sliver was produced.

(217) The number of times the material is passed through the machine and the draught to which it is subjected varies, as was shown, with the class of cotton treated. Thus, the harsh, wiry varieties of cotton stand more drawing, but if well drawn will spin fairly well into weft, which does not receive so much twist as warp, and should be full bodied. How much any class of cotton should be doubled and drawn is a matter to be determined by practice only, and even then great variations in the course pursued will occur. The one thing which must be remembered is that as soon as an even sliver is produced further drawing is unnecessary, and only results in a diminution of the strength of the spun yarn.

(218) A necessary corollary to the process of doubling slivers is the provision of means whereby the passage of all the combined slivers is ensured throughout their entire length. Assuming, for instance, that eight ends were being passed through the machine, and one of them from some cause failed, it is clear that the delivered sliver would be diminished in thickness one-eighth. Of course the attendant would rectify this at the earliest moment, but, in the interim, a large amount of the thin sliver might have been produced. In order to avoid this serious evil, it is the practice to fit all machines of this class with a detector motion, which operates on the failure of any of the ends. Referring now to Fig. 123, it will be seen that, after passing through the guide-plate F, the sliver is conducted over the end of the short lever G, which oscillates on a knife-edge bearing. The end over which the sliver passes is hollowed out, and is highly polished, while the other end—which is slightly heavier—is beneath a curved guide-plate, shown in section. The lever G is balanced so that the pressure of the sliver during its passage is sufficient to keep the spoon-shaped end down, while, on the breakage or failure of the sliver, the lever oscillates on its bearing. A reference to Fig. 124 will show that a shaft H, driven from the main shaft, as shown, has on it an eccentric, to which the rod I is attached. This rod is attached to a bell crank lever J, on the shaft K, which is oscillated, and thus gives a reciprocal movement to the levers L, carrying a square bar. A bell crank lever M is also placed upon the shaft H, and ordinarily engages with a snug on the stop rod N. The latter has a helical spring attached, which always tends to pull it longitudinally, and when it is released, to throw over the strap from the fast to the loose pulley.

(219) Assuming now that one of the slivers has failed, its spoon lever will oscillate and its weighted end will fall. It thus comes in the path of the reciprocating bar in the lever L, which is prevented from completing its traverse. The result is that the lever M is oscillated and the stop rod N released, so that the spring named at once throws the strap on to the loose pulley and stops the machine. As the reciprocations of L are very rapid, no considerable length of the sliver can pass without causing the stoppage of the machine. The attendant is compelled to piece up the broken end, and "single" is thus prevented.

(220) The sliver may, however, fail between the drawing rollers and the delivery can, and it is therefore necessary to provide a means whereby the machine can be arrested in this event also. In its passage to the can the sliver is collected by a trumpet-mouthed tube and carried over another spoon lever O, balanced and borne exactly as the lever G. The failure of the sliver is followed by the fall of the inner end of O, which comes in the path of the lever P, to which a lateral reciprocal motion is given from the shaft H, as shown. This results in the stoppage of the machine exactly as in the case of the back stop-motion.

(221) After passing the detector lever, the sliver goes through another tube and is compressed by the calender rolls Q, driven as shown in Fig. 124. These give the sliver more cohesion, and slightly flatten it, after which it is treated by the coiler head R, which is of the same construction as that employed on the carding engine, and is driven by the gearing indicated in Fig. 123. Some makers provide a full can stop motion, which operates when the can gets quite filled with cotton. There is a danger, if the attendant is careless, of it becoming jammed under the coiler plate and serious damage occurring. In order to obviate this, a thin plate is fitted below the coiler plate, thus forming a sort of false bottom. This is weighted suitably for various strengths of slivers, it being desirable to press the sliver to a certain degree in order to get as great a length in each can as possible. The amount of this pressure is, of course, variable, and care must be taken not to make it too great. When the loose plate is raised it lifts a vertical stop which comes in front of a lever coupled to the front end of a lever corresponding to P, in Fig. 124, and the motion of the latter is arrested as before, with the same result. This is the arrangement used by Messrs. Platt Brothers and Co., Limited.

(222) It sometimes happens that a sliver in coming out of the can will be formed into a knot, or loop, which, when it comes into the guide plates, F, cannot pass through the holes in the latter. The result is, that the sliver is broken and requires re-piecing. Now, it is desirable to prevent the breakage of the sliver when possible, and the case named is met by Mr. Brooks by the use of the motion shown in detail separately. The bar fixed in L oscillates under a catch lever S, which is balanced by the plate F, so as to be raised above the path of L. When, however, a knot occurs, the plate F is drawn inward, and the catch lever S brought in the way of the bar in L, the oscillatory movement of the latter being arrested. The machine is thus stopped, as in the cases previously named. In order to make this movement more sensitive, the plate F is balanced by the weighted lever fixed on the same rod on which F oscillates, the weight being adjustable to suit different strengths of sliver.

(223) Messrs. Howard and Bullough have for some years made an application of electricity to this machine for the purposes of stop motions. Their arrangement is shown in Fig. 127, in transverse section. The machine is practically divided into two pieces, which are joined together, but have pieces of some insulating material introduced into the joint. One half of the machine thus constitutes one pole, and is connected to the battery, or dynamo, by the rod R; and the other half being the other pole, also coupled to the battery by the rod O. The sliver, as it passes to the back roller, goes between two rollers S T, which are coupled to the positive and negative poles respectively. The lower roller is fluted and is the

full length of the machine, while the upper roller is only long enough for two slivers. Failure of an end is followed by the contact of the two rollers, thus establishing the circuit and causing a current to pass through the magnet X, which attracts the catch Z. The latter engages with a constantly revolving cam and thus stops the latter, this being followed by the release of the knocking-off lever. The lapping of a sliver in passing through the drawing rollers causes the top front roller H, which is coupled to one pole, to engage with a pin L, connected to the other, and so stop the machine. The breakage of the sliver before

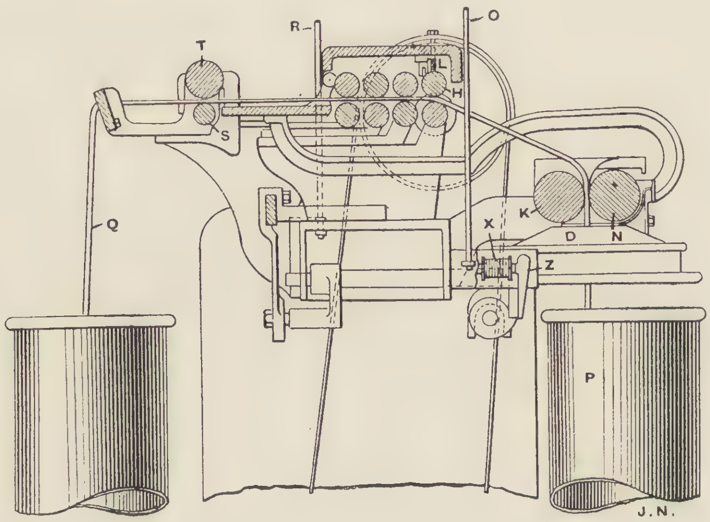


Fig. 127.

reaching the calender rollers N K, is followed by the establishment of contact between them, with the usual result. Over filling of the can lifts the tube plate in the coiler O, and completes the circuit with the same result. The use of electricity in this connection has greatly simplified the machine, and has proved to be a great success.

(224) It only remains to be said that the diameter of the front roller is from 1 inch to $1\frac{3}{8}$ inches, according to the work required, and the speed at which it is run, from 290 to 450 revolutions per minute.

CHAPTER X.

SLUBBING AND ROVING MACHINES.

(225) The sliver as left by the drawing frame consists of a number of fibres arranged in a parallel order, and contains a little twist introduced by the coiler. It is not practicable to carry the parallelising process much further, as the drawn slivers are so attenuated that very little more draught would pull the fibres asunder. As, however, it is essential, in order to produce a yarn of the requisite fineness, that a further reduction shall be effected, it is the practice to gradually introduce into the sliver a small amount of twist. This is done by stages, and at each stage the partially twisted fibre is subjected to the action of drawing rollers. The machines about to be described, therefore, have a dual action, and, in most cases, are three in number, known respectively as slubbing—second slubbing or intermediate—and roving frames. While this is the rule, it is not the universal practice. In spinning coarse counts, for instance, only the first and third of the series are sometimes employed, while the production of very fine yarns is aided by the use of a fourth machine, known as a "jack" frame. Whatever may be the number of steps by which the process is completed the object is the same—to reduce the sliver to an even round thread of such proportions that it can be readily twisted into yarn of the requisite diameter. The introduction of a slight twist binds the fibres together, and enables them to be drawn as required without breakage. The thread finally produced is technically known as a "roving." The various machines being practically identical in their details, varying only in correspondence with the increasing fineness of the thread, it is only necessary to give a description of one of the series.

(226) In Fig. 128 a front view of a slubbing frame, and in Fig. 134 a back view of a roving frame, as made by Mr. John Mason, are shown. The sliver is brought from the drawing frame in the cans in which it is coiled, these being placed at the back of the slubbing machine. It is drawn from the cams over a guide roller, and is then conducted to the drawing rollers. After being treated in the slubbing frame the bobbins produced are placed upon wooden pegs, pointed at both ends, which are sustained in bearings in the light frame S shown in Fig. 134, this being known as a "creel." The bobbins are borne in an almost vertical position, and revolve easily as the slubbing is being drawn off. There may be two or three rows placed in the creel, which is described as a one, two, or three height creel accordingly. In either case the material is conducted as in the slubbing frame to the drawing rollers. Of these there are usually three, but sometimes four lines, their construction being generally similar to those used in the drawing frame, the back set of top rollers being ordinarily heavier than the front ones. The rollers are carried in brass bearings, fixed to the roller beam, and are weighted as in the drawing

frame. Top clearers are fitted above the rollers, which are quite covered by polished cast-iron covers. The bottom rollers are kept clean by the aid of a revolving clearer kept closely pressed against them by a two-armed spring, the ends of the arms being grooved to form bearings for the axes of the clearer roller. The "under clearer" spring is attached to the roller beam, and is usually made of flat steel, stamped out of a sheet. A better form, made from round bright wire, has been recently introduced by Mr. C. H. Pugh, of Birmingham, which has the great merits of catching less fly and being more easily cleaned. As was said in the previous chapter, the absolute cleanliness of the rollers is essential, as otherwise the sliver will adhere to them—this being known as "licking"—and will be wrapped round them, thus producing "roller laps." The drawing action having been fully described in the preceding chapter, it is not necessary to go over the same ground. The diameter of the front rollers in the slubbing frame are about $1\frac{1}{4}$ inch, and in the roving frame $1\frac{1}{8}$ inch. The weights are heavier in the slubbing frame, and in all the series the back rollers are more lightly weighted than the front. Thus the weights used for the front, middle, and back lines in the slubbing frame are respectively 18, 14, and 10lbs; in the intermediate frame 14, 10, and 8lbs.; and in the roving frame (with single bossed rollers) 10, 8, and 6lbs; and (with double bossed rollers) 18, 14, and 12lbs.

(227) The mode of constructing the spindles A, is illustrated in sectional elevation in Fig. 129. The spindles are made from round steel from $\frac{9}{16}$ inch to $\frac{7}{8}$ inch diameter, and are arranged in two rows, one behind the other, with their centres alternating thus . ˙ . ˙ . . This arrangement permits of more spindles being fitted into the space at liberty. Usually the distance from centre to centre of adjoining spindles denotes the "guage" of a machine, but in the series of machines now being dealt with, the peculiar setting of the spindles prevents this. The "guage" in this case is denoted by the number of spindles in a defined number of lineal inches. Thus, to take an illustration from actual practice, a slubbing frame may have 4 spindles in $17\frac{1}{2}$ inches, that being its guage; an intermediate, 6 in $19\frac{1}{2}$ inches; or a roving frame 8 in $20\frac{1}{2}$ inches. The spindles are accurately ground so as to be quite round, and vary in length from 28 to 42 inches. At the "foot" the diameter of the spindle is reduced, and the extreme lower end or "toe" is conical, being borne by a brass footstep fixed in a longitudinal rail. Immediately below the bobbin is an upper bearing or bolster, fixed in a similar rail. On the top of the spindle a flyer B is placed, this being of the shape shown, and constructed of steel. The legs are oval in section, and may be either tubular or solid, being made as light as possible. At the centre of the bridge connecting the legs is a circular double boss C, which is bored throughout, the hole so formed being carefully rounded and polished at its upper orifice. At a point near the top a hole is bored penetrating to that in C, and being also well rounded and polished. The lower portion of C constitutes a socket, into which the upper end of the spindle fits, the latter passing above the point at which the bridge is attached to the boss. A slot is cut across the upper end of the spindle, and a round pin, engaging with the slot, is fixed in the socket of the flyer, which is thus positively driven.

(228) Attached to one or both legs of the flyer are two snugs or projections $D\ D^1$ acting as bearings for pressure fingers or "pressers" E. The latter are round rods, hooked at their upper ends and bent at right

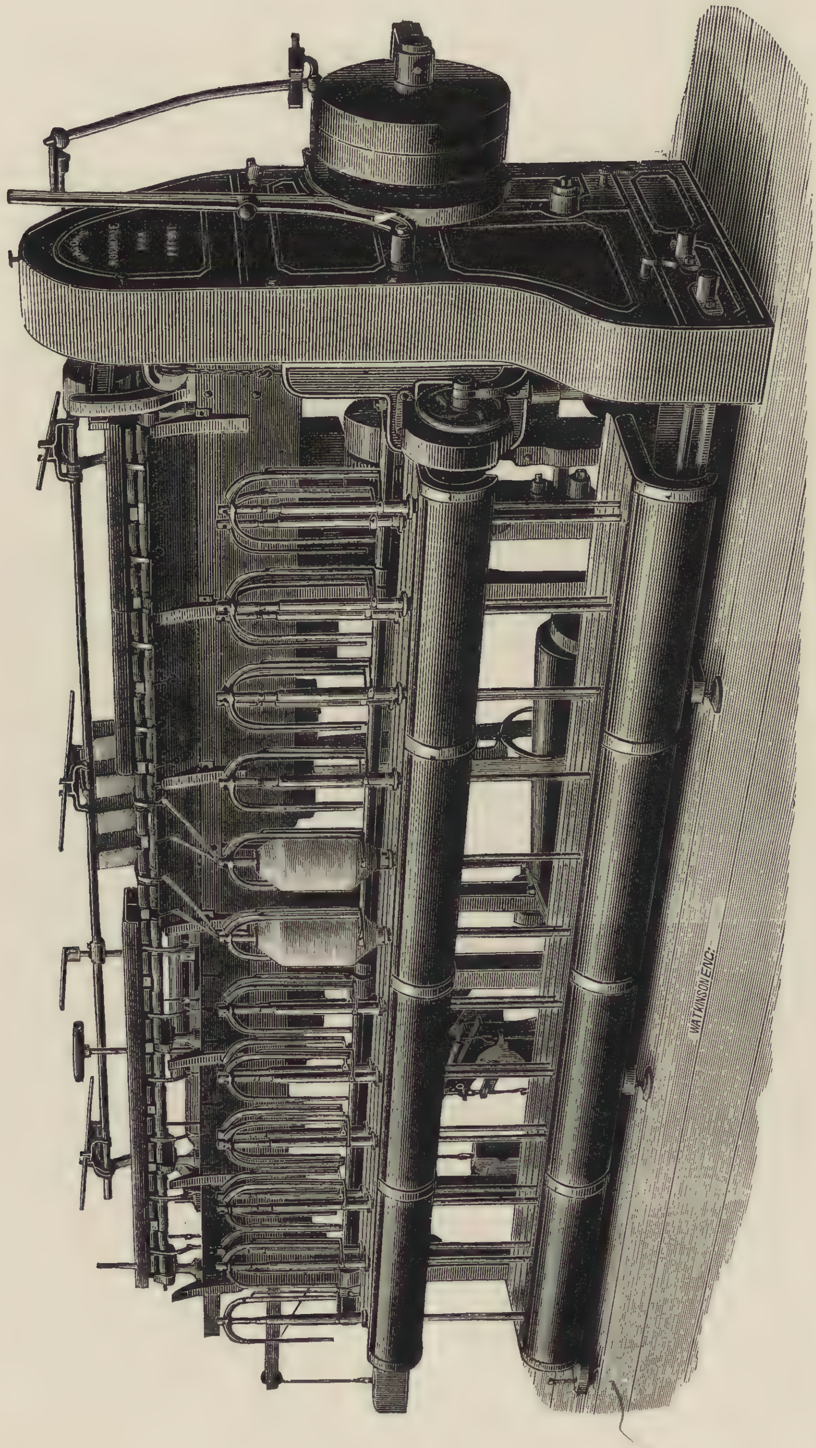


FIG. 128.

angles at their lower ends. The hooked portion can be dropped into a socket in the upper snug D, and the presser thus oscillates freely on the centre of the bearings D D^1. The inner end of the finger E is flattened and curved so as to correspond with the surface of the bobbin F, being formed with a guide-eye, as shown. It is made of such a length as always to press upon the surface of the bobbin during the

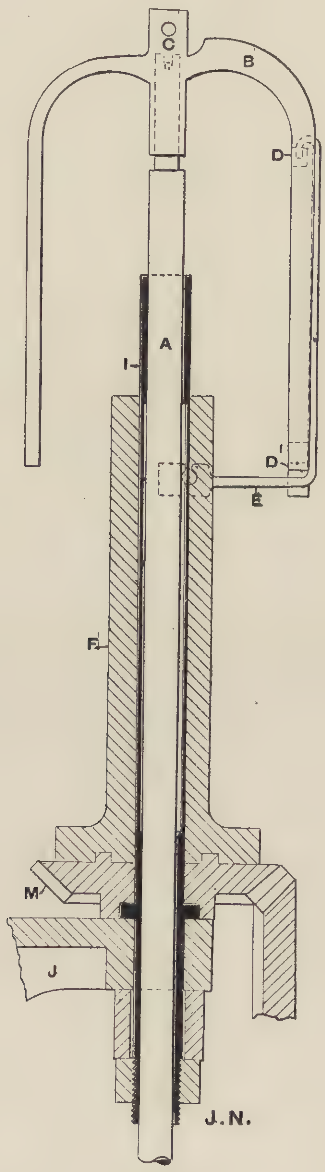


FIG. 129.

rotation of the flyer, which it is caused to do by the centripetal action set up by the latter. The amount of pressure exerted depends entirely on the rate of the revolution of the flyer, and the practical effect is that the roving is more tightly wound on the body than it would otherwise be. It was at one time

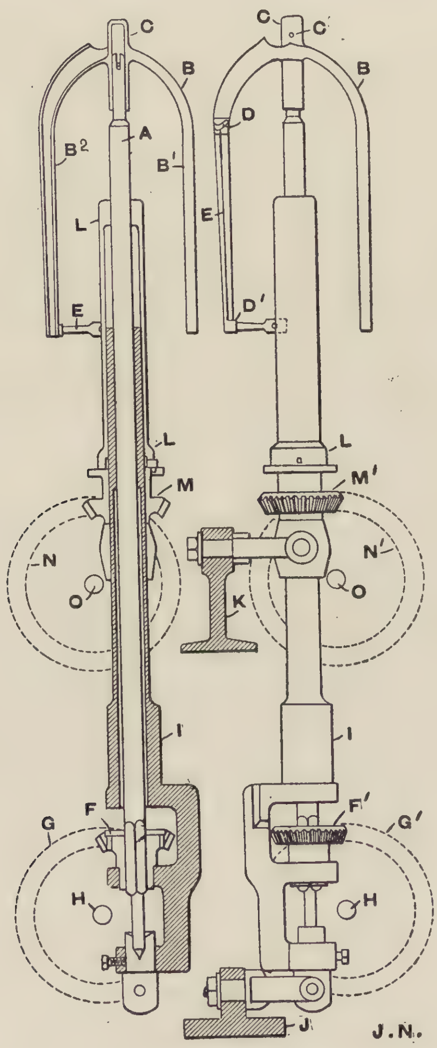
customary to use two pressers with each flyer, but it is more generally the practice now to employ one only. Great care is taken to balance the flyer, and, when single pressers are used, one leg is made solid and the other tubular, the presser being fitted to the latter. The sliver, after leaving the rollers, is passed through the upper part of the boss C, emerging by the small hole referred to, being then wrapped round the presser two or three times, and finally conducted through the guide-eye in the finger to the bobbin F. Both the inner and outer surface of the flyer must be absolutely smooth, as otherwise it catches the fibre and forms "fly." For this reason, steel, as a constructive material, has entirely superseded the fine iron formerly used.

(229) The spindle is borne, as was shown, by a bolster and footstep. In order to give steadiness and reduce friction it is the practice to fit in the former a collar or tubular bearing. This is either "short" or "long." Formerly short collars were the rule, these merely acting as a somewhat longer bearing, the bobbin in its vertical movement sliding upon the spindle. Mr. John Mason then introduced the "long" collar which is shown in Fig. 128. The collar I is of sufficient length to extend from the bolster, bearing upwards through the bobbin to a point within the flyer. It is recessed internally, so as not to bear the entire length, but simply to be in contact with the spindle at two points. The latter is thus sustained high up, in addition to being borne, as usual, at the two lower points. The effect is that a much less amount of vibration is set up, and the flyer revolves with greater steadiness. This has an important bearing upon the operation, as it diminishes considerably the risk of breakage.

(230) Another method which, in many respects, is superior to any other, is that shown in Figs. 130 and 131 in vertical section and elevation. This is the plan previously adopted by Messrs. William Higgins and Sons, and now made by Messrs. Crighton and Sons, and Shepherd and Ayrton. In this case the spindle A is carried in a long tube I, which extends downwards until it is formed, as shown, into a footstep for the spindle toe. In short, the spindle is sustained in a kind of tubular cradle, being to a certain extent entirely free of the fixed bearing rails J K. To these the tube I is attached by swivel joints, so arranged that they are universal, thus allowing the spindle A and flyer B to adjust themselves as required to compensate for any unevenness of balance which may exist in the bobbins or flyers. The tube I is recessed for a certain part of its length, so as to form an oil chamber and reduce the friction set up during work. The advantages arising from this arrangement are that, even when the spindle is running at high velocities, any untrueness in the balance of the spindle merely causes it to find its true centre of gravity, and thus avoid vibration or wear. Spindles constructed in this manner can be worked for many years without showing any wear which is at all detrimental, and on this account higher velocities are attainable with ease than can be reached with the ordinary methods of construction.

(231) The spindles are positively driven as shown in Fig. 130, by means of bevel wheels fastened near the foot. In the arrangement shown in these drawings the spindle pinions F are formed with square holes, into which the spindles, similarly shaped, are fitted. This allows the spindle to be easily lifted out when required for examination. Usually the pinions F are fastened to the spindle by means of a set screw. In either case they engage with a bevel wheel G fastened on a shaft H, carried in brackets fixed to the framing, and extending

longitudinally along the frame. The spindles being set zig-zag, as described, there are two lines of them, and consequently there must be two shafts H to drive them, and in order to distinguish between the two, they are supposed to be shown in position in Fig. 131, and the back wheels are marked F^1 G^1. The shafts H are geared so as to revolve at the same velocity, but in opposite directions, and, as it is imperative that the spindles shall



FIGS. 130 AND 131.

revolve in the same direction, this is attained by gearing the pinions F F^1 on different sides of the centres of the wheels G G^1, as clearly shown. To enable this to be done, the teeth of the wheels are cut at a special angle or "skew" to suit.

(232) The bobbin L rests upon a flange of the bevel pinion M placed on the collar, and driven by the wheel N. The pinions are, as shown in Fig. 129, fixed in the "bobbin rail," or, as in Fig. 130, carried on the top of a

bearing sustained by the swivel joint. The upper flange of each pinion has formed on it oblong "snugs" or projections, which take into corresponding slots made in the bottom of the bobbins. The wheels N are keyed on the shafts O, which also extend the whole length of the machine, and are suitably borne by brackets fastened to the underside of the bobbin rail. Thus the latter sustains both the driving shafts and the bevel pinions which, as in the case of the spindles, are driven by wheels gearing at different sides of the centre.

(233) This mode of construction lends itself very easily to the formation of the bobbin or spool of roving, which, at its completion, is of the shape shown in Fig. 128, cylindrical with conical ends. In order to wrap the yarn upon the bobbin L it is necessary to give the latter not only a rotary but a vertical movement. It is, of course, possible to give this motion to the spindle and flyer and not to the bobbin, but this is not a convenient method in the case of machines like those under notice, for many reasons. The rail, therefore, which carries the bobbin pinions and bobbin, known as the "bobbin rail," receives a vertical traverse to an extent which is determined by the class of material to be dealt with. This traverse is a reciprocal one, and is technically known as the "lift," a machine being said to have a lift of so many inches according to the extent of the vertical movement of the bobbin rail. This varies from 10 or 12 inches in the case of the slubbing frame to 5 or 6 inches in the roving frame, and is obtained in a manner which will be presently described. While it is taking place the bobbins are slid upon the spindle, the presser eye continuing to revolve in the same horizontal plane. From this it follows that any yarn drawn through the eye by the rotation of the bobbin is of necessity wound upon a fresh portion of the surface of the latter. It only remains now to point out, before proceeding to deal with the machine in detail, that it has been shown the spindles and bobbins are driven independently, and may, if desired, rotate at various and different speeds; and that provision is also made for the maintenance of the vertical position of the spindles and flyers while permitting that of the bobbin to be altered. These, added to the regular delivery of sliver by means of the rollers, constitute the essential features of these machines, but the effective manipulation of them gives rise to a number of interesting mechanical problems.

(234) It has been pointed out that the action of the rollers in attenuating the sliver is identical with that of those in the drawing frame, so that no special description need be given of them. But these machines are the first in which the process of twisting is carried out, and the rollers form an important part of the mechanism for this purpose. In introducing twist into any strand or sliver it is necessary that one end of it should be held, while the other is also held and turned at a higher or lower speed. If this is done the strand will be twisted, and the amount of twist is strictly defined by the number of times it is turned. In actual working it is not practicable to continue so to twist the strand without at the same time submitting it to the action of the spindles continuously. Unless it was so delivered it would be broken because of the shortening which takes place during twisting, and it is therefore necessary to furnish a fresh portion of the sliver to the action of the twisting mechanism. For this reason the sliver, while being firmly held by the nip of the front rollers, is also delivered by them at a definite rate, which depends on their size and rate of revolution. Now, assuming that no such delivery takes place, and that a length of sliver of 10 inches is turned 100 times, there would be in each inch of it 10 turns or twists. Suppose, now, that another 10 inches was delivered and the same number of turns

made, a similar result would be obtained. It does not matter whether the delivery is constant or intermittent, provided only that the ratio of the length delivered and the number of revolutions of the twisting mechanism remain the same. Intermittent delivery would, however, be very inconvenient in practice in producing rovings, and thus it is requisite to provide for a steady and regular delivery of yarn, as well as a uniform speed of the spindle and flyer. Granting the attainment of these conditions, it is easy to define the amount of twist put into any thread, it being in the same ratio as the number of revolutions made by the twisting mechanism during the delivery of one inch of sliver or roving. Twists are always defined as being so many "turns" per inch, and are arrived at in the way just indicated. As a matter of fact there is a little slip in the rollers, which does not, however, to any large extent modify the rule enunciated. The constants in a machine of this kind are therefore the rate of revolution of the spindles and front rollers; and, generally speaking, the amount of twist increases as the roving becomes finer. This can be attained by an increase of spindle speed or a decrease of that of the rollers, as will be readily understood, but considerations of a mechanical nature generally lead to the latter course being pursued. The spindle speeds in a slubbing intermediate, and roving frame, dealing with the same class of roving, would be approximately 700, 800, and 1,100 revolutions per minute. A table of productions, speeds, etc., is given on page 174, which will throw some light on this point.

(235) It has been already noticed that the bobbin receives a vertical traverse, while the spindle is vertically stationary, and that, in consequence, the yarn is wrapped upon the bobbin in spiral coils. The speed of this traverse is carefully regulated so that each layer is quite free from any overlap, while, at the same time, no space should be left between the coils. When the bobbin has wrapped round it for the whole of its length one layer of roving, its diameter is increased by an amount equal to double the thickness of the roving. Thus its circumference is enlarged, and every revolution it makes requires a longer length of material to cover the surface than it did when it was bare. This extra amount must either be fed to the bobbin, or its speed must be reduced, and as the rollers deliver at a constant rate, the latter is the course pursued. Further, the length of roving wrapped upon the bare bobbin during the whole lift is, of necessity, less than that which would be wrapped upon it after a layer has been wound on if the lift were constant. It is essential that the length of each complete layer should be as nearly as possible equal, and for this reason the traverse of the bobbin is shortened slightly after each of its reciprocal movements. The amount of the diminution in lift is in exact correspondence with the excess of length which would be taken up if it remained constant. The increase in the diameter of the spool has thus an important bearing on the lift, and it is of equal moment in relation to another function of the machine.

(236) A reference to Fig. 129 will show that the flyer and bobbin rotate round the same centre, and the roving delivered by the rollers is passed on to the bobbin through the presser eye, as pointed out. If it be assumed that the yarn passes on to the bobbin at some imaginary point in the circumference of the latter, and that this occupies during its rotation a definitely relative position to that of the flyer eye during its revolution in a concentric circle, it follows that no roving can pass from the flyer to the bobbin. A little thought will make this clear, but Fig. 132 will serve to illustrate it. In this figure, A is the

spindle, B the circumference of the bobbin, and C the path of the flyer eye. Now, as A and C are attached in the manner previously described, they must of necessity revolve at the same speed. On the other hand, the rate of rotation of B is capable of variation by reason of its independent driving. Let D and E represent respectively the points at which the yarn leaves the flyer C and passes on to the bobbin B. It is obvious that if the relative position of D and E remain unchanged—that is, if they travel at equal speeds, so that the line between them is always alike—there can be no passage of roving from D to E; or, in other words, there can be no winding. But if the point E makes a complete revolution in less time than D does, or *vice versâ*, winding will take place. In the first case the quicker motion of E would result in the bobbin B taking up roving from D; and in the second the greater velocity of D would cause it to wrap the roving round the bobbin. To make this clear, suppose the lines A D and A E to

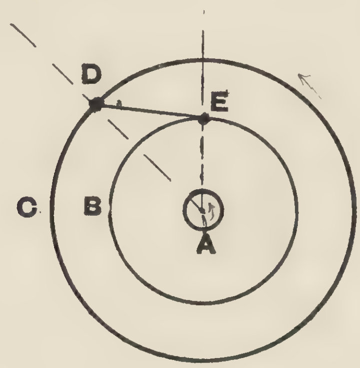


FIG. 132.

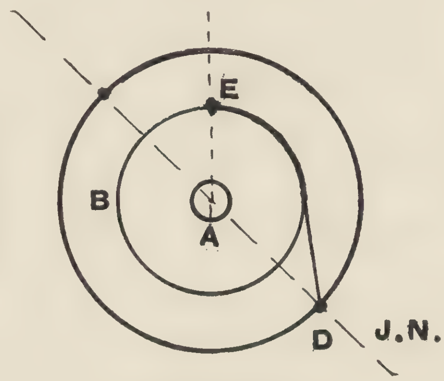


FIG. 133.

represent radial lines drawn through the points D E at the commencement of winding, and that at the termination of say three revolutions, the position of these lines relatively is the same. It is perfectly clear that the line D E will have remained unaltered, and no passage of the roving will have occurred. But now assume that the flyer C had moved so much faster than the bobbin B, that the radial lines through D and E were in the position shown in Fig. 133. It will at once be seen that C will have drawn forward a certain length of roving corresponding to its gain, and that the portion of its circumference between the point where the material from D passes on to it and the point E will be covered by the roving. In the event of B moving faster than C, the effect is identical with that described, although it is obtained in an entirely different way.

(237) This statement of the general principle is sufficient to show the conditions under which winding is successfully effected. The gain either of the bobbin or flyer upon the other is technically called the "lead," and thus a frame is said to be constructed with a bobbin or flyer "lead." The determination of the amount of lead is very simple, and is fixed by the speed of the rollers, it being manifestly impossible to take up more yarn than is delivered. It follows, therefore, that the excess of the surface speed of the bobbin or spool at any stage of its development must accurately correspond with that of the front rollers. If this condition be departed from, either by the lead given being too great or too little, the result will be

broken yarn; in the first case by stretching, and in the second by the production of slack places which become entangled and broken. It may here be stated that it is now almost universally the practice to let the bobbin lead, as, with the flyer leading, a certain amount of stretch is put into the yarn, which is very injurious. This defect is especially noticeable in starting the frame, and it is entirely remedied by giving the lead to the bobbin.

(238) Assuming, then, that the bobbin leads, it is necessary to consider the effect of the gradual increase in the size of the bobbin, caused by the winding on of the yarn. This difficulty is rendered acute by reason of the positive driving of the bobbin. In flyer frames, used for spinning or doubling, the bobbin has a little slip which can be easily adjusted, but which is not obtainable in this case. The slip of the bobbin is caused by the drag of the yarn, a procedure which at this stage is practically impossible. Every traverse of the bobbin rail is, as has been seen, accompanied by an increase of the circumference of the bobbin corresponding to the diameter of the roving. Thus, to take an extreme case, assuming the diameter of the empty tube to be $1\frac{1}{2}$ inch, it would take up at each revolution 4·7 inches of yarn. If the yarn was $\frac{1}{8}$ inch thick, the diameter of the bobbin would be $1\frac{3}{4}$ inch after one layer, and each revolution would take up 5·5 inches of yarn. This is, of course, assuming that the flyer is absent, and that the bobbin was winding. As the surface velocity of the bobbin and front roller must correspond, and no more sliver is delivered at one time than at another, it follows that the rate of revolution of the bobbin must diminish in exact proportion to the increase of its circumferential speed. It is, therefore, easy to calculate the exact amount of retardation at each traverse by a knowledge of the diameter of the yarn, or the number of layers to be wound on any spool.

(239) It is thus easy to see that with the bobbin leading it should gradually diminish in speed, and it is consequently the practice to run it at a much higher speed at the beginning than at the termination of winding. For instance, an empty spool 1 inch diameter takes up per revolution 3·1416 inches of roving, while one 3 inches diameter would take up 9·42 inches. It thus becomes imperative to reduce the speed of the bobbin wheels, and these being constantly geared with their driving wheels, it is necessary to reduce the velocity of the bobbin shafts. These are driven, as described hereafter, by a train of gearing from the main shaft, and special means are adopted to compass the reduction. The spindles are running at a constant speed, and it follows, in consequence, that the bobbin must run at the same rate, plus the number of revolutions necessary to take up the length of yarn delivered in any given time. If, for instance, the spindles made 100 revolutions while 10 inches of yarn was being delivered, the bobbin must revolve 100 times plus the number necessary to take up the 10 inches of yarn.

(240) When the flyer leads, the application of this principle is not quite so clearly seen at first sight, but a little reflection will make it understood. In this case the winding is effected by the excess of the speed of the flyer over that of the bobbin. This is exactly the reverse of the practice when the bobbin leads, but the essential condition is, as before, the preservation of the relative surface speeds of the bobbin and roller. Suppose that, in starting, the diameter of these two are the same, then the bobbin must lag behind the flyer to the extent of one revolution for each revolution of the roller. But as the bobbin increases in diameter, it requires more yarn to cover its surface, and a less

difference in speed is needed, as, if the bobbin continues to lag one revolution, the difference between the speed of delivery and that of winding become so great as to stretch and break the roving. Instead of wrapping it round, for instance, a circumference of three inches it has eventually to be wound on one of six inches, and it is obvious that if the speed of the bobbin remains constant the roving will be drawn and broken. It is, therefore, necessary to gradually increase the speed of the bobbin so that for every inch of yarn delivered, an inch of the circumference will be covered by it. The difference between this and the former case consists in the fact that the roving is wrapped on a concentric surface, revolving in the same direction at a slower speed, while, with the bobbin leading, the surface on which the roving is wound, moving in excess of the speed of the flyer, draws the roving through the flyer eye at a rate equal to that of its delivery. In other words, it is in one case *wrapped* on by the excess of the flyer speed or the drag of the bobbin, while, in the other, it is *drawn* on by the excess of speed of the bobbin. The conclusion is thus arrived at that when the flyer leads, the bobbins must start at their slowest speed, and gradually increase; while, when the bobbin leads, it must begin at its highest speed and gradually diminish.

(241) Having thus explained the principle of the machine, it now remains to describe the mechanism by which it is carried into effect, referring for this purpose to Fig. 134. The driving, or "jack," shaft A has a fast and loose pulley on its outer end, and has fastened on it two spur wheels. One of these drives, by means of a carrier wheel, a wheel fixed on one of the spindle shafts, and motion is given to the spindles in the way previously described. The speed of the spindles, being independently obtained, can be changed without reference to the other motions. The pinion C is known as the "twist wheel," and is made as large as convenient. It drives, by the intervention of a carrier wheel, a pinion D fixed on the shaft on which the cone E is also keyed. The shaft carrying D has also fastened on it, within the framing, a pinion which directly gears into a wheel fixed on the roller axis. Thus the twist wheel C drives the cone E and the rollers, so that if it is replaced by a smaller wheel, both of these revolve at a lower speed, or *vice versâ.* This is important, because as the speed of the rollers and that of the bobbins are both regulated from the twist wheel, the alteration of their velocities is made simultaneously.

(242) This part of the mechanism is easily understood and involves no difficulty, but the driving of the bobbins gives rise to a complex problem which necessitates the employment of some ingenious mechanism. The upper cone E drives, by means of a strap or band, the lower cone E^1. The circumferences of each of these cones are accurately turned to corresponding, but converse, parabolic curves, one cone being convex and the other concave. They must be exactly the same in their largest and smallest diameters, and are turned in lathes fitted with "former" plates, by which the slide rest is guided in its correct path. The lower cone is carried in bearings B, formed in two arms connected by a tubular stay, oscillating on a shaft (M, Fig. 134), on which is the pinion H. This arrangement is shown separately in plan and elevation in Figs. 135 and 136. A pinion G is fixed on the spindle of the lower cone, and gears with a spur wheel F fastened on the shaft named. Thus, when the cone E^1 is raised or lowered, the pinion G rolls round its engaging wheel F, being always fully in gear. This arrangement is utilised to keep the strap tight, the lower cone being

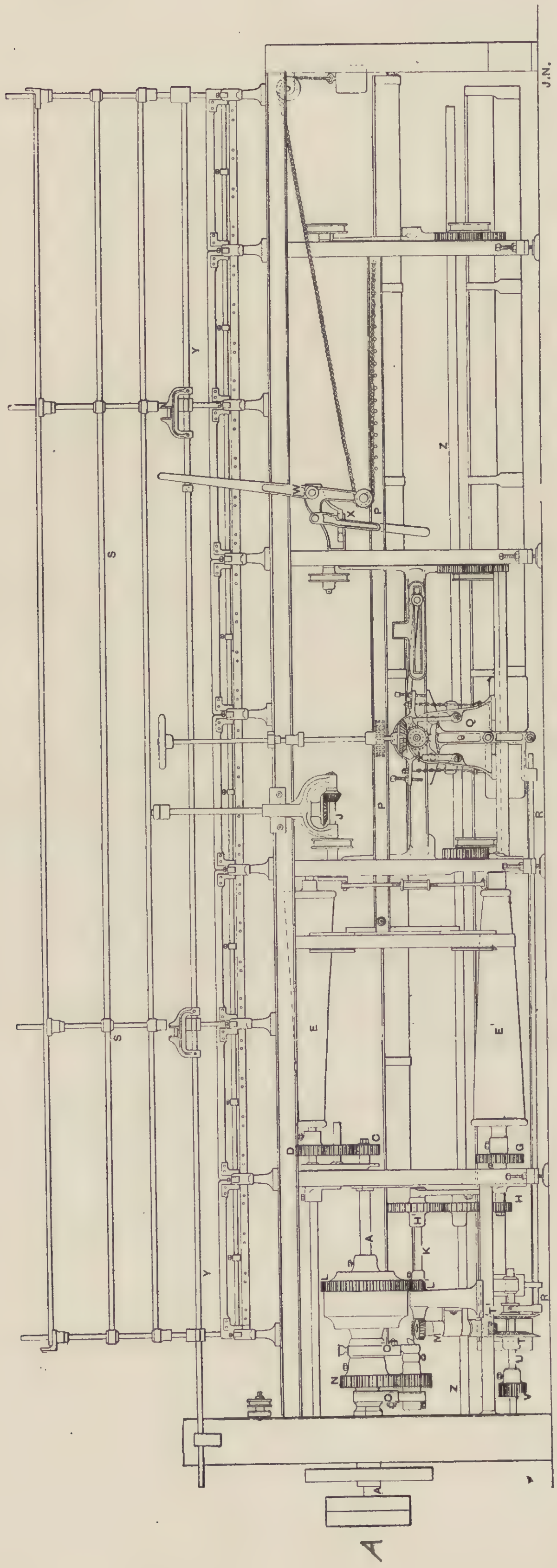
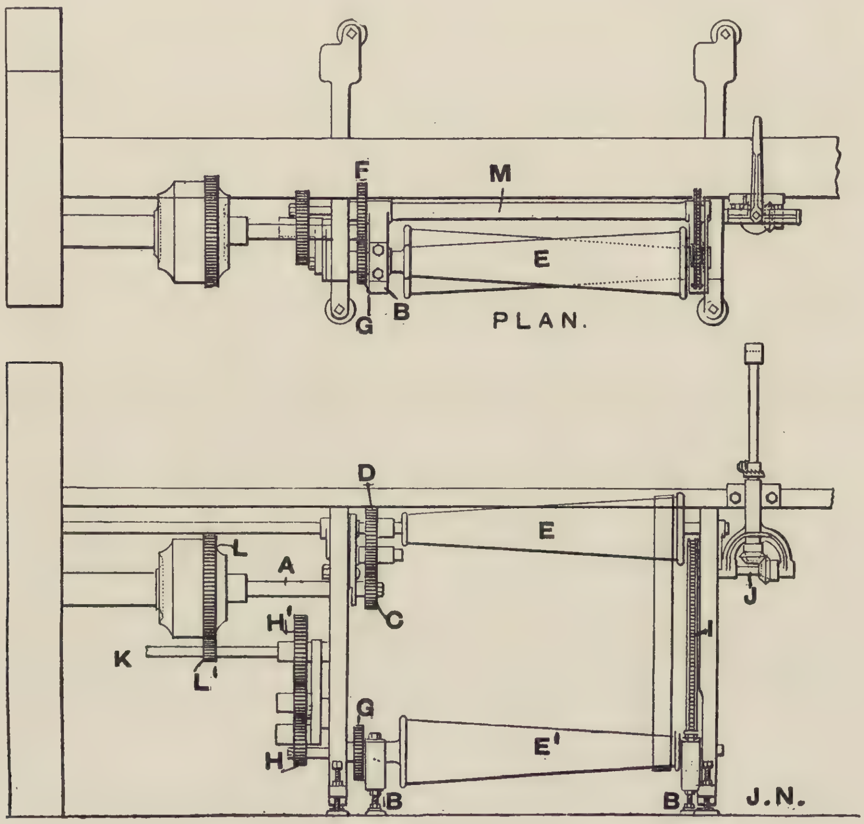


Fig. 134.

coupled by an adjustable connecting rod or chain I to a disc fixed on the cross shaft shown, the former being preferable. By revolving the shaft J, the cone E^1 can be raised or lowered, and the tension on the strap can be regulated by means of a right and left-handed nut which couples the two parts of the connecting rod I, Fig. 134. Motion is given to the pinion H, as will be easily understood, from the cone E^1, and from it to



FIGS. 135 AND 136.

the shaft K by the carrier pinion which gears with H^1 on K. On K also is fixed a spur pinion L^1 driving the plate wheel L, and the worm which engages with the worm-wheel on the upright shaft M. The latter is thus revolved, its precise function being explained hereafter.

(243) The wheel L forms a part of the ingenious winding, or, as it is sometimes called, "the differential motion," invented by Mr. Henry Holdsworth. This is one of the class of epicyclic wheel trains, of which many instances are known and which are very interesting. Fig. 137 is a drawing on an enlarged scale of this motion, the reference letters, with the exception of L and N, being used for this figure specially. Upon the shaft A a fixed cast-iron tube is placed, upon which the wheel L and the compound wheel D N revolve. The jack shaft A revolves in the tube, and on the shaft is fastened a bevel wheel B which gears with similar pinions C and E. These are carried in bearings formed in the wheel L at equal distances

from its centre, and have perfect freedom of revolution. They also engage with the bevel wheel D, cast in one piece with the spur wheel N, which is known as the "bobbin wheel." The latter gears with a spur pinion carried in a double swing frame O O^1 (Fig. 134), centred on the jack shaft and attached at its other end to the bobbin rail. In this way, as the latter rises and falls, the swing frame or "swing"—as it is shortly called—oscillates on its centre, and the spur pinion rolls round the bobbin wheel N, being always in full gear. By means of a carrier wheel—also borne by the swing—the motion of the bobbin wheel is communicated to a spur wheel on one of the bobbin shafts, and by equal sized pinions on each shaft to the other. Thus, the bobbins are driven by a train of wheels, which are always in gear, no matter what the vertical position of the bobbin may be. The bobbin wheel and its compound bevel run loose upon the cast-iron tube, as previously stated.

(244) The foregoing description of the winding motion will serve to show the principle of its construction, and its mode of action can now be explained. Suppose first, that the bearings of the pinions C and E are fixed instead of revolving with the wheel L, and that the shaft A is revolved, it is obvious that the revolution of the wheel B would be communicated to C and E. These would rotate on their axes, and would consequently drive the wheel D N at the same speed as B, but in the opposite direction. This may be called one pole of the operation of this motion. The other is reached when the plate wheel L is rotated in the same direction as B at an equal velocity, the wheel D N being then carried round in the same direction, and at the same speed as B. But if the relative velocity of L is reduced, there will be a lessened speed communicated to the wheel D N in the proportion of two revolutions less than that of B for every revolution of L. That is to say, if B was running at 20 revolutions per minute and L in the same time made one revolution, D N would make 18 revolutions. This gives rise to a curious result in working. When the number of revolutions made by L is half of those made by B, the motion of D N entirely ceases, but as the proportion is varied so as to be slower than B, the velocity of D N is reduced as described, but its direction of rotation will be different. That is, if L makes more than half as many revolutions as B, the wheel D N will move in the same direction as B; but if it makes less than half, D N will rotate in the opposite direction to B. This motion is admirably treated in Professor Goodeve's "Elements of Mechanism," where its rationale is fully described, and where the student will find ample explanations of the operation of this class of mechanism. It is sufficient for the present purpose, however, to reiterate that the loss of motion in the bobbin wheel D N, is equal to two revolutions of B for each one of L; and that the direction of motion of D N depends on the speed of L. It may be said, in amplification, that when L revolves at less than half the speed of B, the velocity of D N increases as that of L decreases; while if the plate wheel L makes more than one-half the number of turns of B the speed of D N increases with that of L. The middle point thus becomes a sort of zero, a fact which it is desirable to remember. Treated algebraically, the formula may be stated as follows, where $b =$ the velocity of the driving pinion B, $l =$ that of the plate wheel L, and n that of the bobbin D N, if L revolves in the same direction as the shaft, $n = b - 2l$; but if in the contrary direction, then $n = -b - 2l$.

(245) The effect of the application of this formula in the latter case is different entirely to the results already described. If the wheel L revolves at the same speed as B, but in the contrary direction, then

$n = -3b$, if the value of b be substituted for that of l. If L makes half the number of revolutions that B does, then $n = -2b$. The relations of B and D N can thus be accurately ascertained, and by the aid of this formula the speed of the bobbin wheel can be easily calculated. It is only necessary to know the value of the entire train of gearing from the fixed wheel B to the plate wheel N to be able to apply the formula given above. Thus, if it is found that the ratio of the velocity of L and the fixed wheel B be, say, as 1 : 40, and that B makes 250 revolutions per minute, the speed of D N could be arrived at easily.

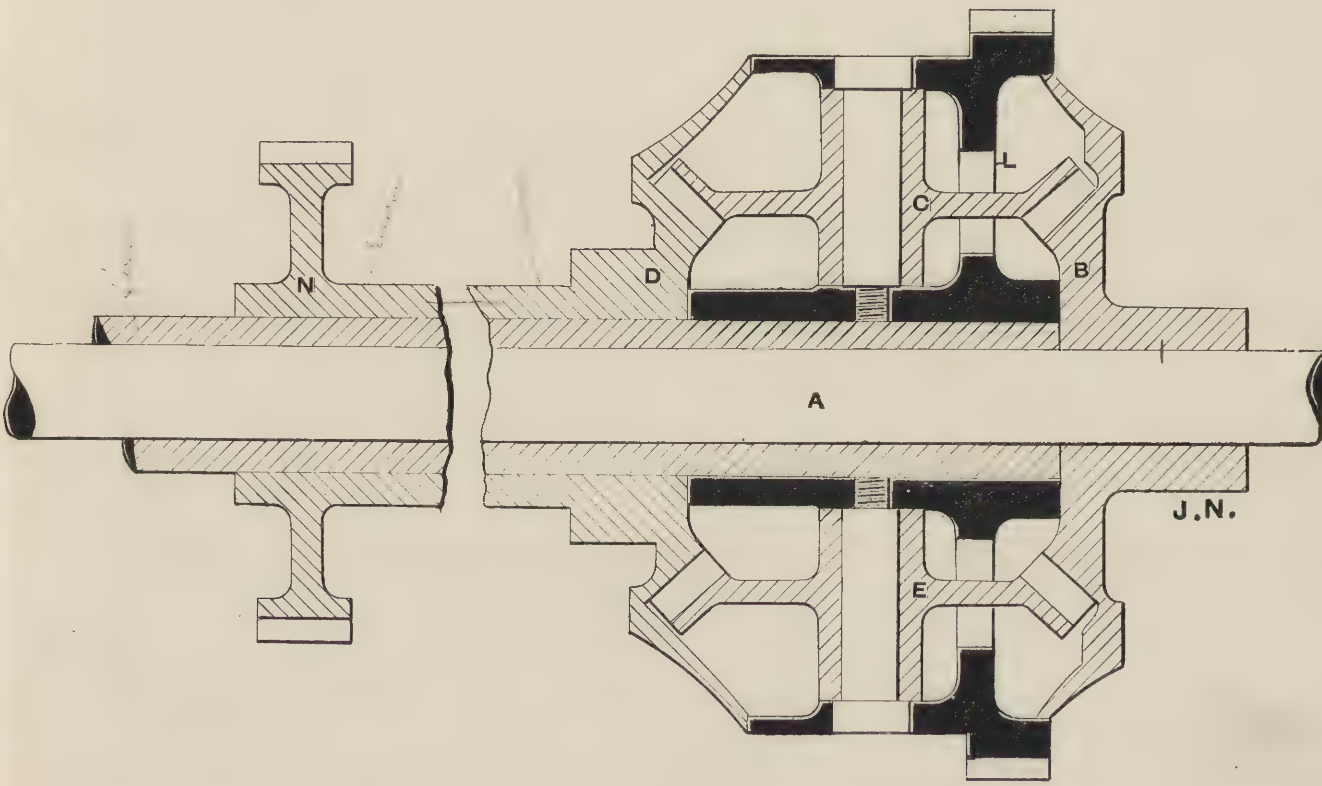


FIG. 137.

Substituting the arithmetical value of l and b for those signs, the result would be $n = 250 - 2(\frac{250}{40}) = -262{\cdot}5$. As the changing position of the cone strap is the only variable factor in the problem, it is only necessary to know the diameters at various points to ascertain accurately the reduction or acceleration of speed which will occur during the time it is making the necessary traverse. It should be explained, before passing on to deal at greater length with the practice of the subject, that the minus sign merely indicates that the bobbin wheel revolves in a contrary direction to the wheel B and the shaft A.

(246) The application of this mechanism to the purposes of winding depends, therefore, upon the regulation of the speed of L. It has been seen that the motion of the latter is derived from the bottom cone E^1. Assuming the plate wheel to run in the same direction as the wheel B, it follows that when the bobbin leads, the

wheel L must start at its slowest relative speed, and increase as the bobbin fills. It is for many reasons desirable that the speed of the plate wheel should be as low as possible, which is the course generally adopted. If the flyer leads, the opposite plan is pursued. When, as is the case in the machine made by Mr. John Mason, the plate wheel revolves in the reverse direction to that of the wheel B, it commences at its quickest and finishes at its lowest relative speed, with a bobbin lead. Under these circumstances the full value of the special arrangement, illustrated in Fig. 137, is seen. The highest velocity of the cone is obtained when the bobbins are empty and have in consequence the lightest weight. Where spindles are revolving at 800 to 1,000 revolutions per minute, this is undoubtedly a great consideration, because the strain upon the strap is lessened by reason of the decreased velocity at a time when the strap is on the smallest diameter of the driving cone. It is sometimes the practice to run L and D on the bare jack shaft in the contrary direction, this creating a good deal of friction and necessitating extra driving power. For this reason the introduction of a tubular bush, such as is shown in Fig. 137, is attended with considerable advantage. The friction existing when the wheels run upon the bare shaft, but in the contrary direction, is very great, as will be understood when the speed of the wheels—about 400 revolutions per minute—is remembered. Any rotation of one or more of the wheels in the opposite direction to the shaft is therefore equal to an increase of the friction on the latter by the rate of the movement of the former.

(247) To overcome this defect, therefore, the motion has been re-arranged in one or two cases, so that all the parts revolve in the same direction. Messrs. Curtis, Sons, and Co. employ Curtis and Rhodes' motion, which is illustrated in section in Fig. 138. The bobbin wheel A is cast in one piece with, or fixed to, an

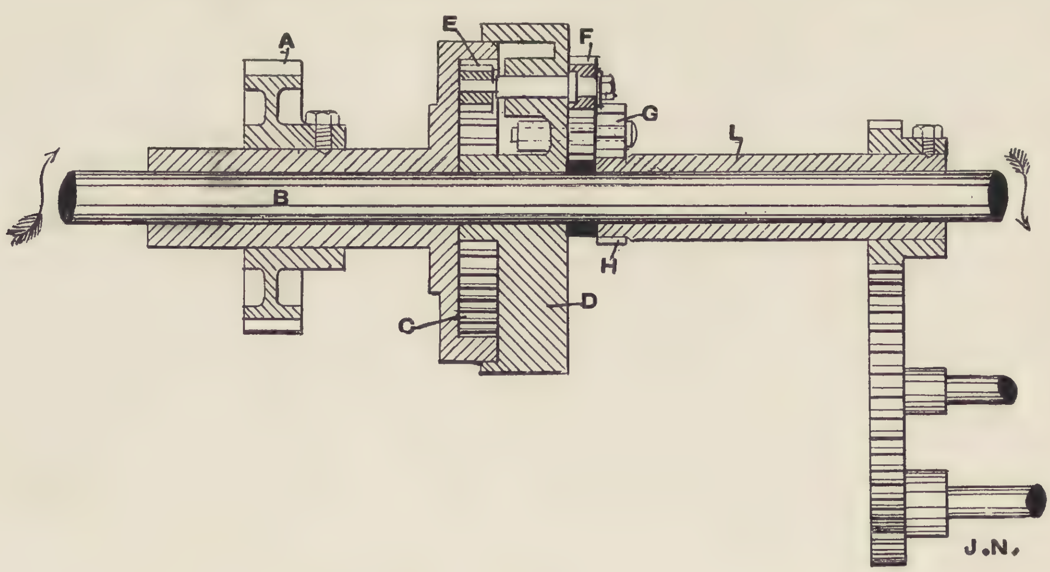


FIG. 138.

internal wheel C, which is loose upon the shaft B. The disc D is fastened on the shaft, revolving with it, and carrying a pin or spindle, on each end of which are fastened the pinions E and F. E gears with the internal wheel, and F with a compound pinion G, which in turn engages with the pinion H. The latter is

cast on the collar L, which is driven from the lower cone and is loose upon the shaft B, revolving in the same direction. If the collar L is fastened to the shaft, the whole of the wheels become locked together, and the bobbin wheel A and the driving pinion H will revolve together at the same speed and in the same way. This arises from the fact that the disc D is fixed on the shaft, and as it carries the train of wheels the fastening of L keeps the teeth of E and F locked, so causing the rotation of the latter and its attached wheel A. The carrier wheels would be standing under these conditions, while the Holdsworth motion in the same circumstances would have the whole of the wheels in rapid motion. Thus, if in actual work, when the collar L is loose, it is revolved at the same speed as the disc D or at one nearly approaching it, there would be no motion in the carrier wheels, or very little, and the speed of A would equal that of H. As the velocity of the latter is reducing, more motion is given to the wheels, which thus retard the wheel A while allowing it to rotate in the same direction as the shaft. In this way the wear and tear of the parts, and the power required to drive them, are alike materially reduced.

(248) Messrs. Howard and Bullough use Tweedale's motion, which is illustrated in Fig. 139. The shaft A has a boss fastened on it, which is constructed with a second boss G at right angles to, but on one side of it. The latter is bored to receive a short shaft, on each end of which the two wheels F H are fixed. The wheel B is driven from the lower cone, and is compounded with the bevel wheel E, both being free to revolve on the shaft. The bobbin wheel C is cast in one piece with the wheel D, and also runs loosely upon the shaft. It will be noticed that only the wheels F and H are positively rotated on the shaft A, being carried round with the boss. The

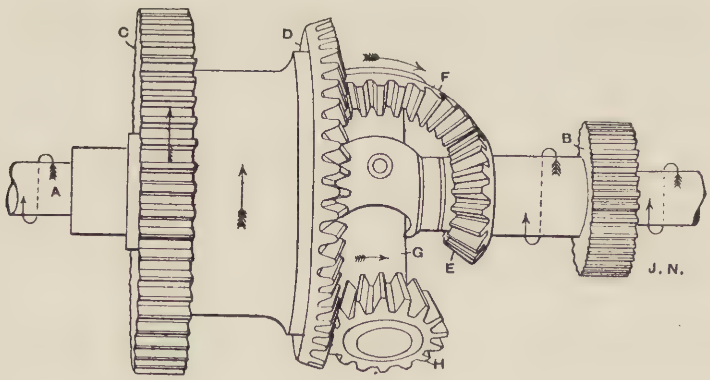


Fig. 139.

motion is communicated from E to D as follows: E drives the wheel F, thus rotating the short cross shaft and the pinion H. The latter gears with and drives the wheel D, the pinion F acting merely as a carrier. The action of this mechanism can be readily understood from the preceding explanation, and it need only be pointed out that the regulation comes from the wheel B. There is introduced into this mechanism the element of a double set of driving and driven wheels. Thus G drives the wheel F, and H D, so that there is a difference between this and the Holdsworth motion, in which the intermediate pinions act as carriers only. In order,

therefore, to get the speed communicated to the wheel D, it is necessary to multiply the number of teeth in the driving wheels and divide by those of the driven, by which means the proportions of the two are arrived at. By the use of the following formula the speed of D can easily be arrived at. Let m = revolutions of the shaft, n = revolutions of the pinion B, which is variable, a = the constant arrived at as above, and v = the speed of bobbin wheel D, then $v = m - a(m + n)$. Having obtained the speed v it is of course easy to calculate the necessary wheels to give the speed of the bobbins.

(249) The operation of the differential motion is controlled, as has been seen, by the lower cone, the speed of which is carefully regulated by altering the position of the driving strap laterally. It has been pointed out that the cones are correspondingly but conversely curved, the reason for this being that the actual increase which takes place in the diameter of the bobbin is not in the same proportion to the actual diameter at the end as at the beginning of winding. There is a slight decrease occurring as the bobbin fills, and in the early stages of spinning it was the practice to use a rack with uneven teeth cut to a parabola, which was a costly process, and is entirely avoided by the use of cones of that shape. Further, it is found that the bite of the strap is better during a change of position. It will be readily understood that the position of the strap on the two cones determines the speed of the plate wheel L. It is therefore essential to provide means by which the traverse of the strap can be effected, and, as the addition of one layer of roving implies the necessity for a change in the bobbin speed, the movement of the strap is given at the termination of each lift, at the moment of the change of traverse. It follows, therefore, that the mechanism by which the strap is moved, and that by which the reversal of the lift is effected, must be connected. Before proceeding to describe how this is done it may be stated that the strap passes between two guides fastened to the toothed rack or slide P (Fig. 134), sustained by bearings fixed to the frame of the machine. The operation of traversing the rack is performed by an interesting piece of mechanism which has several functions.

(250) The "building motion," or "box of tricks" as it is sometimes called, is placed in the position shown in Fig. 133 by the letter Q. In order that its details may be better understood, a front and back elevation and plan of it is given in Figs. 140, 141, and 142, to which special reference will be made. The objects of the building motion are three-fold: 1st, to give the requisite traverse to the cone strap; 2nd, to give the reciprocal traverse to the bobbin; and 3rd, to shorten that traverse or lift at the termination of the winding of each layer. It has been already explained why the two first objects have to be attained, and it will be profitable to explain the reason for the third. Suppose that in commencing winding the tube is $1\frac{1}{4}$ inches diameter, the lift say 10 inches, and the diameter of the roving $\frac{1}{8}$ inch, there would be wrapped upon that surface during one lift 80 coils or 314 inches of roving. Now, assuming that four layers have been wound, the diameter of the bobbin would be $2\frac{1}{4}$ inches, which, if the lift remained constant, would cause 563 inches to be wound on the surface. But as the rate of delivery by the rollers is definite during the time occupied by the lift, it follows that such a length of roving could not be wound. It, therefore, becomes necessary to reduce the lift after each layer of yarn is wound, so as to compensate for the increased area of the cylindrical surface, and provide that the whole of the length delivered by the rollers is taken up, but no more.

(251) Referring now to Figs. 140 and 141 it will be noticed that there are two cradles A and B, centred respectively on the pins A^1 and B^1. Fixed in the upper cradle A are hooks, one at each side, which are connected, as shown, with double hooks C D, passing through ears on the lower cradle B, having weights attached to their lower ends. The lower cradle B has fixed in it a pin E^1, engaging with a slot in the lever E. E is centred on the pin F, and is coupled at its lower end to the rod R, which is connected with the double bevel wheel T T, this connection being shown in Fig. 134. Two catches G G^1, centred at their lower ends to the frame carrying the cradles, are coupled by

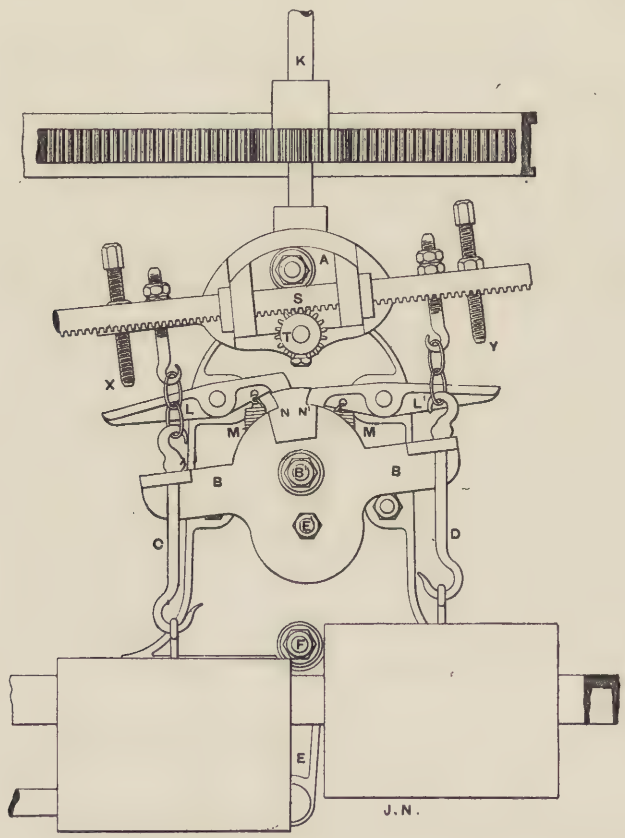


FIG. 140.

the helical spring H. It will be noticed that the pawls of the catch levers are differently shaped, so as to engage with the teeth of the rack or ratchet wheel I on the upper and lower side of the centre respectively. The rack wheel is fixed on the same centre as the cradle A, as is also a bevel pinion J, gearing with a similar one J^1 fixed on the upright shaft K, Fig. 141. At a higher point on K a spur pinion P^1 is fastened, which gears with the teeth on the rack P, controlling the strap guides. Two levers L L^1 are pivoted to the frame as shown, and are coupled at their inner ends by a helical spring M, which is carried round the centre B^1. The inner ends of L L^1 engage with shoulders or corners N N^1, formed in the

lower cradle B. Fixed to the bobbin rail is the double slide Q, which has a pin O sliding in it, on which the end of the connecting rod S is centred. This rod passes through bearings placed in the cradle A (see Fig. 140), and is formed with a toothed rack at its lower side with which a wheel T fixed on the pin A^1 gears. These are the whole of the parts of this particular mechanism, but a reference to Fig. 134 will show that the rack P has a weight attached to it by a chain, which is always tending to draw it inwards, and move the strap. In addition to this it causes a torsional strain to be exercised on the shaft K, and consequently on the rack wheel, which causes the latter, when released by the catches, to rotate.

(252) The action of this mechanism is as follows: The slide Q in its reciprocal vertical movement causes by means of the "diminishing rod" or "hanger bar" S, the upper cradle A to oscillate in its centre. When the bobbins are midway in their lift, the centre of the slide Q should be in a line drawn horizontally through the centre of the pin A^1, and the rod S should be capable of being moved horizontally without producing any oscillating movement in the cradle A. When this is the case, the two levers L L^1 engage respectively with the shoulders N N^1. Assuming that the bobbins are descending, the cradle A is turned from left to right when looked at from the back of the frame as in Fig. 141. In this way the hook D is raised with its pendant weight, while C is simultaneously lowered. As the shoulder on the upper part of the hook C prevents it passing through the hole in the ear on the cradle B, it follows that a pressure is exercised on the latter, which causes it to turn in the same direction as A. The weight attached to D is finally completely taken off the cradle B, and the continuance of the movement causes the point of contact of L and N to become the fulcrum by which the rotary movement of A is arrested for the time. This movement closely resembles the action of an anchor, the cradle B being practically fixed as a ship is by its anchor. In some modifications of the mechanism this resemblance is more pronounced than in the one immediately under notice. Thus the point through which D passes continues to be free, while the whole weight is thrown upon the hook C, which thus exercises a proportionate strain on B. The continued oscillation of A in the direction indicated causes the screw X, fixed in the left hand arm of A, as shown in Fig. 140, to come into contact with the outer end of the lever L. The increasing pressure so applied causes L to turn upon its centre, destroying the contact of its inner end with the shoulder N, and allowing the cradle B to make a sudden movement, which is partially rotary, but is also vertical in character. The movement being reversed, the parts assume the position shown in Fig. 140, shortly after the reversal. The screws fixed in the arms of the cradle A can be readily adjusted and locked so as to make the release of the lower cradle B simultaneous with the termination of the bobbin traverse.

(253) In consequence of the sudden release so effected, the lever L^1 assumes the position shown in Fig. 140, and at the same time the pin E^1 strikes one side of the hole in the lever E (see Fig. 141), and causes the latter to turn rapidly on the pin F. This is followed by three things. The head of the lever E strikes the catch G^1 and throws it out of gear with the ratchet wheel. The latter at once makes a rotary movement to the extent of half a tooth, but is then arrested and retained by the catch G. As the catch levers G G^1 are coupled by the spring H it will be easily understood how the movement of one of them to the right or left is accompanied by a corresponding movement of the other. By this release of the ratchet wheel and its partial revolution, the upright

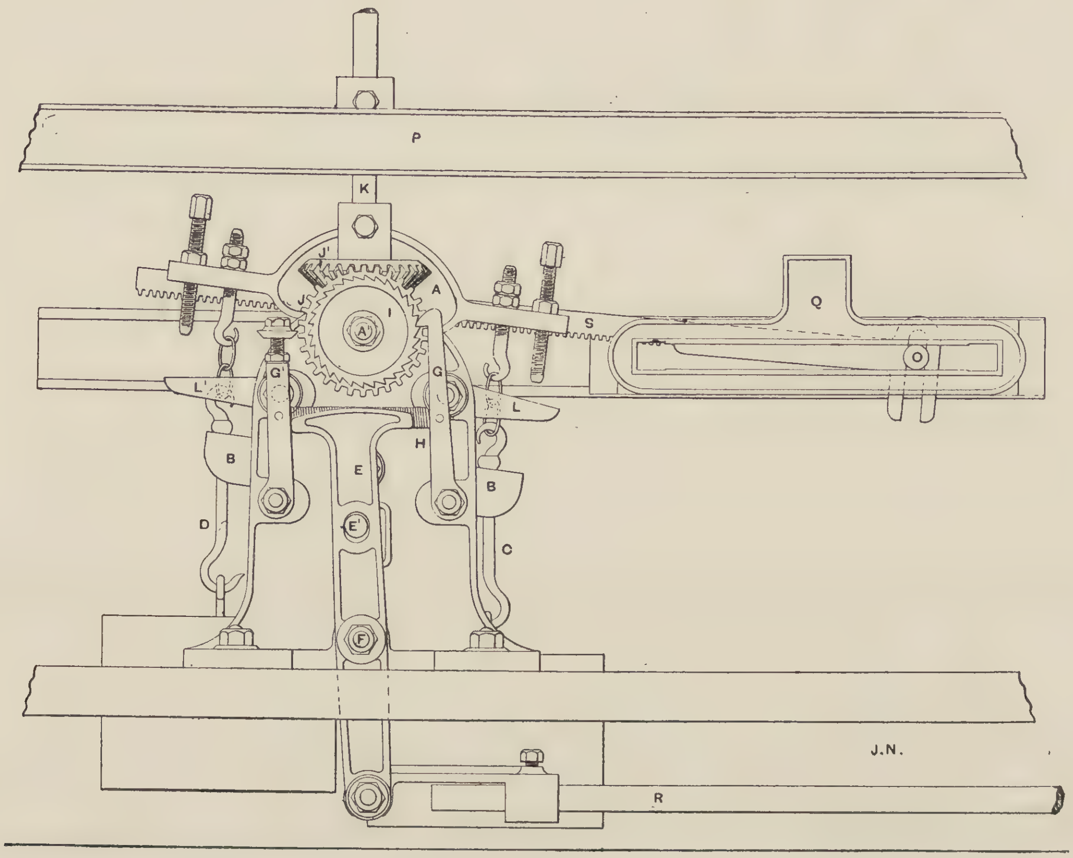


FIG. 141.

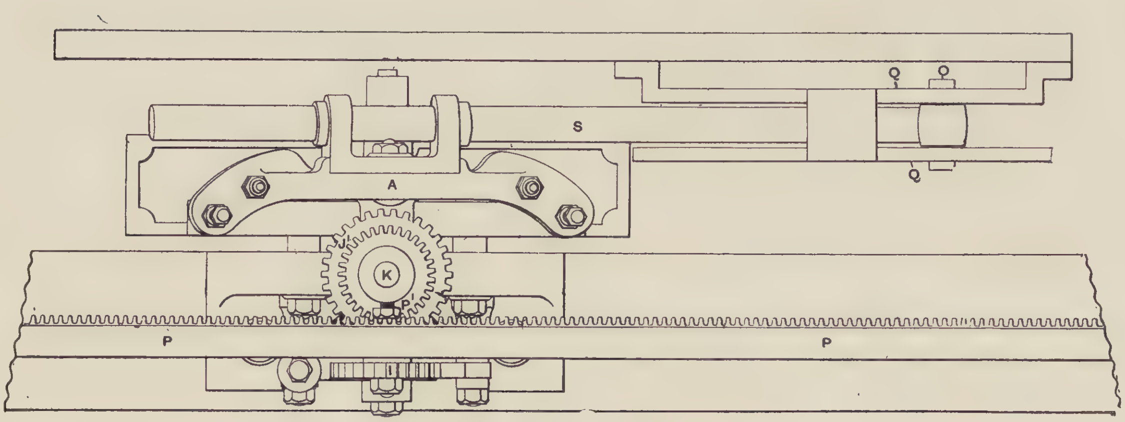


FIG. 142.

shaft K also moves and causes the rack P to travel inwards and so move the strap on the cones. This is the first effect of the movement of the lever E.

(254) As shown in Fig. 134, and also in Fig. 141, the lower end of the lever E is attached to the rod R, which is connected at its other extremity by a forked lever to the double bevel or "striking" wheel $T\ T^1$. The latter engage alternately with the small bevel pinion fixed on the lower end of the upright or "change" shaft M and slide upon a short shaft U, which they drive by means of a feather key. On U is also fixed a spur pinion V which drives, by the intervention of suitable gearing, a shaft running longitudinally and placed just behind the spindles. This shaft has a number of spur pinions fixed on it, which engage with vertical racks or "pokers" fastened to the bobbin frame. In this way the rotation of the pinion V in either direction is followed by the traverse of the bobbins either upwards or downwards. When, therefore, the rod R is traversed by the oscillation of the lever E and the bevel wheels $T\ T^1$ are respectively thrown into gear with the pinion on M, the bobbin traverse in a corresponding direction is obtained.

(255) A further effect which arises from the rotation of the ratchet wheel is found in the fact that the wheel T (Fig. 140) also moves, and as it engages with the rack on the underside of the rod S draws the latter inward As will be readily understood, the position of the pin O plays an important part in the oscillation of the cradle A. If, for instance, the pin were at the extreme point of Q furthest from A, the motion of the latter would be made much more slowly than if O were at the other end of the slide, when, owing to the shorter radius, A would make its oscillatory movement more quickly, and, if Q made the same vertical traverse, A would move through a greater arc. Thus, if O is drawn inwards, it is followed by a more rapid movement of the cradle A, and, as a consequence, the change of the position of the lever E occurs at an earlier moment. This causes the reversal of the traverse of the bobbin rail to take place sooner, and, in this way, each succeeding layer of roving occupies a shorter portion of the bobbin surface longitudinally than its predecessor. Thus the bobbin is built accurately in the double conical shape required, and the shortening of the lift, the necessity for which has been previously demonstrated, is properly effected.

(256) A reference to Fig. 134 will show that the weight attached to the rack P is fastened to the latter by a chain, which passes over a pulley at the lower end of the lever W, which is sustained in position by a catch placed at X. When the rack P has made its extreme inward traverse the catch is released, and the lever W is caused to strike the collar on the rod Y, so as to cause the latter to move longitudinally. As the rod is connected with the driving strap fork, the strap is thrown over on to the loose pulley, and the frame is stopped. Attached to the bobbin frame are chains, to the other end of which balance weights are fastened so as to relieve the work of the lifting pinions. These chains are passed over pulleys fixed to the framing as shown in Fig. 134.

(257) Recurring now to the action of the building and winding motions, it is necessary to note that the number of the releases of the ratchet wheel I correspond to those of the reversals of the bobbin rail, and consequently to the number of the layers of roving. It therefore becomes necessary to alter the wheel I whenever a change in the roving which is being produced is made. As the ratchet wheel is the governing factor in the regulation alike of the speed of the strap traverse and of that of the inward movement of the

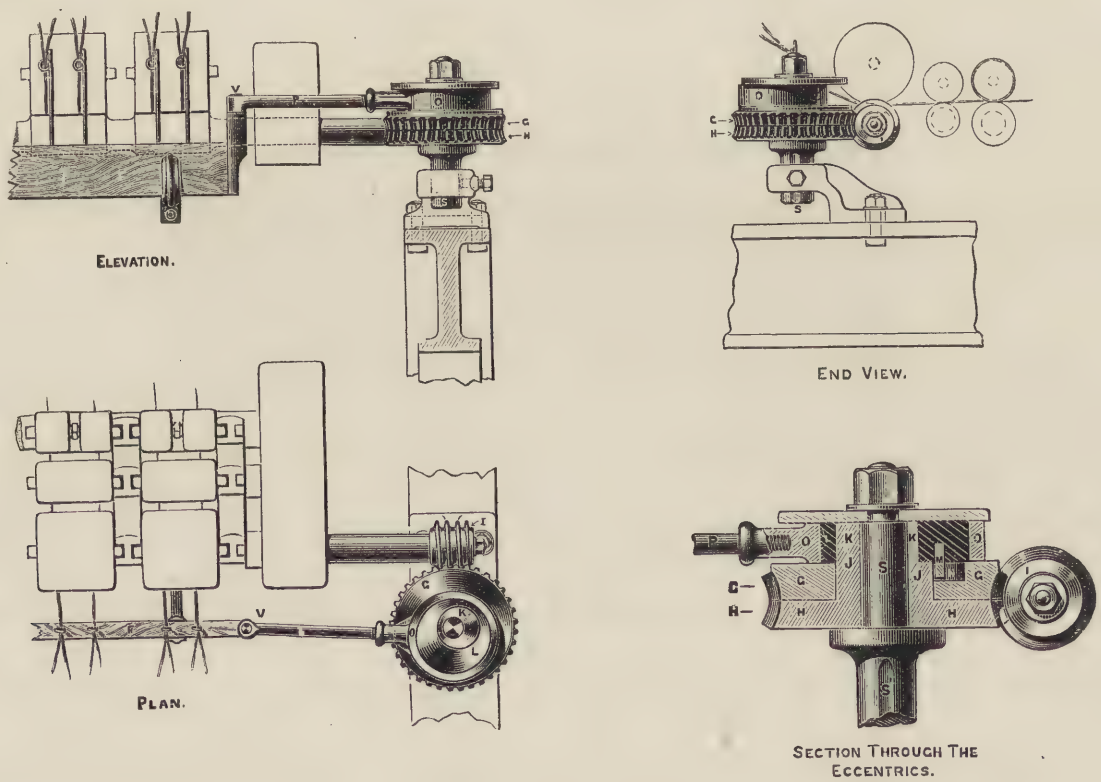
rod S, the reason for changing it is easily seen. Thus the increase in the diameter of a bobbin on which a roving $\frac{1}{16}$th inch diameter is being spun would be less than that which occurs when a roving $\frac{3}{32}$nd inch diameter is made. It follows, therefore, that the rate at which the strap is moved along the cones would in the first case be only two-thirds of that at which it moves in the last case. Again, the lessened increase in diameter involves, as was shown, the winding on of a shorter length of roving during the "lift" of the bobbin, and consequently the latter does not require to be diminished in the same ratio. Therefore, it is desirable to substitute for the ratchet wheel one with more teeth, the number of which must be in direct ratio to the number of coils it is intended to wind on the full bobbin.

(258) Let it be assumed that the pitch of the teeth of the rack P and of that in S is one-quarter inch; that the ratchet wheel I has 30 teeth, the pinion engaging with P 31 teeth, and the pinion T 19 teeth. As was shown, the wheel I moves to the extent of half the pitch of the tooth every time the traverse of the bobbin rail takes place. In this case 60 such reversions would take place during the time that the ratchet wheel made a complete revolution. During that time the wheel engaging with P would also have made a complete revolution, and P would have moved in $7\frac{3}{4}$ inches, giving a corresponding traverse to the strap. In the same time the pinion T would have made a revolution, and the "diminishing rod" S would move in $4\frac{3}{4}$ inches. Assuming—a purely hypothetical assumption—that the distance from the centre A^1 of the cradle A to the outermost point of the slide Q to which the pin O can be pushed is 15 inches, and that the lift of the bobbin be 7 inches, it will follow that the above reduction of the distance of O from A^1 will cause a more rapid oscillation of the cradle A. A simple calculation will show that this would cause the change of the direction of the lift to take place when $4\frac{3}{4}$ inches was covered. This example will serve to illustrate the principle involved, but does not necessarily represent any actually existing case. It is only intended to show that the reduction of the lift takes place in exact accordance with the period occupied by the ratchet wheel I in its rotation. During the time the traverse has been shortened the speed of the bobbin, owing to the traverse of the strap along the cones, has also been diminished in the exact proportion required to compensate for the increased diameter.

(259) Now, if it be assumed that a coarser roving requires producing, and that the ratchet wheel I is changed for one containing only 20 teeth, it will be seen that while the same necessity exists for the full traverse of the strap guide and diminishing rod, a smaller number of layers of roving will be wound in the same time. In this case 40 layers only will be laid, although the strap makes the same movement. That is, the same reduction of the speed of the bobbin is made while 40 layers are wound that was previously made while 60 were wound. Now, as the diminution of the speed of the bobbin must be exactly proportionate to the increase of its diameter, it follows that the roving in the former case must be correspondingly thicker. It should also be observed that the inward traverse of the diminishing rod S is quickened as well as that of the racks P, because the time occupied by the ratchet wheel in making a complete revolution is, of course, less than when one with 30 teeth is employed. Thus the speed of the bobbin and the length of its traverse are both decreased at a more rapid rate when a ratchet wheel is employed, which is exactly what is wanted when coarser roving is being produced.

(260) A locking motion is fitted to the machine by which, when the rack P is released in the manner described, the stop rod is locked in such a way that until the rack has been wound back by hand into proper position the frame cannot be started. There are two advantages in this motion, viz., that the size of the bobbins is accurately regulated, and damage to the frame is prevented.

(261) In order to avoid the uneven wear of the top rollers, caused by the slubbing or roving passing through them at one point constantly, it has become the practice to give a slight lateral traverse to the guide bar. One of the latest developments of this special treatment is illustrated in Figs. 143 to 147, this being the invention of Mr. George Paley, a spinner, of Preston. It consists of a worm I fixed



FIGS. 143, 144, 145, AND 146.

upon the end of the roller spindle, which gears into two wheels G H, carried on a pin fixed in a bracket. The number of teeth in the wheels are different, H having one more tooth than G. In this way G is revolved once for every 24 revolutions of the worm, while H requires 25 revolutions of the latter before making a complete rotation. The wheel H has a boss J, the upper part of which K is formed eccentrically, and on this portion the eccentric L is placed. To the clip of L the traverse rod P is coupled. L is driven from the wheel G by means of a pin fastened in L, and engaging with a slot in G. Thus the rotation of the eccentric L is followed by the traverse of the guide bar.

(262) It will be noticed that the outer eccentric L is not only out of centre with the pin S, but also with the inner eccentric K. Thus the rotation of the latter perpetually establishes a new condition of eccentricity. At one point the throw of the combined eccentrics is smaller than at another, and there are fixed limits within which many positions are assumed. If the throw of K is $\frac{3}{8}$ inch, and of L $\frac{5}{8}$ inch, it is obvious that if they are both at the front centre their combined throw will be 1 inch. But if K is at its back centre and L at its front one the combined throw is only $\frac{1}{4}$ inch. Now owing to the fact that the wheels G and H are made with one tooth more or less, it happens that 25 complete revolutions of the eccentrics are needed before they are brought with their centres coinciding after that position had been abandoned. The result is, that during every one of the 25 traverses a different throw occurs, and the length of the traverse is varied, as shown diagramatically in Fig. 147. By altering the size of the wheels G H any number of variations desired can be obtained.

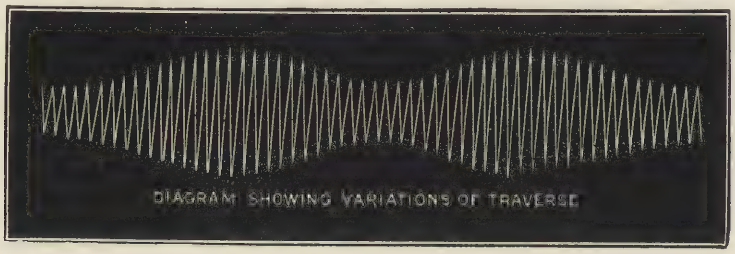


FIG. 147.

(263) Messrs. Howard and Bullough fit to their intermediate frame an electric stop motion. It should be explained that it is customary to pass two slubbings through the rollers at once, twisting them together to form one thread. If from any cause one of these ends breaks, the other may go on twisting, and a thin defective place would result. To obviate this, the arrangement named is applied. The slubbing bobbins are placed in a creel, and are passed between the surface of a metallic spring, and a roller placed at the back part of the machine. The drawing rollers are fixed in their usual position, and the spring is held by a bracket attached to one pole of an electro magnet and battery, the back roller being connected to the other pole. When the thread of slubbing breaks, contact between the spring and the roller occurs, and the circuit is closed. Thereupon a current is passed through the magnet, and one end of a lever is attracted so as to bring its other end in the path of a constantly rotating ratchet wheel. This arrests the motion of the latter, and so releases a catch on the stop rod, allowing it to be drawn along by the action of a helical spring. In this way the machine is rapidly stopped.

PRODUCTION OF SLUBBING AND ROVING FRAMES IN LBS. PER WORKING WEEK OF 56 HOURS.

Hank Roving.	Speed of Spindles. Revolutions Per Minute.	Twist per Inch.	Production.	Maker's Name.
·50	600	·85	114	John Mason.
·50	600	·85	116	Crighton and Sons.
·50	700	·84	115	Howard and Bullough.
1·00	700	1·20	56	John Mason.
1·00	700	1·20	56	Crighton and Sons.
1·00	700	1·20	59	Howard and Bullough.
3·00	1000	2·08	17	John Mason.
3·00	1000	2·08	16	Crighton and Sons.
3·00	1100	2·07	16·53	Howard and Bullough.
6·00	1400	2·94	7·25	John Mason.
6·00	1300	2·94	7·20	Crighton and Sons.
6·00	1100	2·92	6·25	Howard and Bullough.

NOTE.—The velocity of the spindles and amount of twist introduced will largely influence the productions as given above, which are only illustrative of the capacity of these machines.

CHAPTER XI.

THE MULE.

(264) The last process in the production of yarn is that in which the rovings, obtained in the manner described, are elongated and twisted into a thread. To many persons this is known as "spinning," although strictly speaking, that phrase is applicable to the whole range of treatment by which cotton is converted into yarn. Using the term, however, in its narrower sense, spinning may be either an intermittent or continuous operation, that is, the rovings can be twisted for a portion of the time only during which the machine is working, or for the whole of that period. Although the latter system is the most ancient, for the last century the former has been more generally pursued. It is, therefore, advisable to describe first the machine by which it is carried out.

(265) This is known as the "mule," and owing to the practical automaticity of its mechanism, as the "self-acting" mule or "self actor." It is without exception the most interesting of the whole series of machines used in cotton manufacture, combining an intricate sequence of mechanical movements with great ingenuity. As a further consideration will show, one piece or part of the mechanism used performs work widely diverse in its character at different periods, and it is this fact which renders the mule so difficult a machine to understand. The time occupied in completing the cycle of operations which constitute mule spinning is so small that the action of the various parts must be very rapid and certain. In order to understand the description which follows, it will be advisable to define the stages or periods which succeed each other and form the entire process.

(266) In order to facilitate the grasp of the subject by the reader, it will be better to describe first and briefly the essential or primary parts of the machine. These are shown in Fig. 148, which is a purely diagrammatic representation. The roving bobbins A are fitted on a skewer and placed in the frame or creel arranged at the back of the machine, being held in an almost vertical position. The roving R is guided as shown to the nip of triple lines of drawing rollers B B B. From the rollers the roving passes to the tip or point of a steel spindle H, sustained by an upper bearing or bolster O, and a foot-step N. These are fixed in wooden rails which form part of a box or frame I, known as the "carriage." The carriage is fitted at convenient distances along its length, with cross brackets, in each end of which bearings are formed for the axes of the pulleys or runners P. These rest upon the edges of oblong iron bars or "slips" Q, which are securely fastened to the floor of the room. The spindle receives a rapid rotary motion, being driven by a band M, carried tightly round a small V grooved pulley or "warve" fixed on the spindle, and a light roller K extending longitudinally of the carriage, and fastened on a shaft T. The roller—or more correctly the "tin roller"—K is suitably driven, and, it will be easily understood that the direction and velocity of H will depend upon those of K. In its passage to the spindle the roving is taken under a small guide wire D--known as the

"faller wire" or shortly the winding "faller"—fastened on the outer end of a curved arm or "sickle" secured on the shaft F—known as the "faller shaft." The roving also passes over a second wire C—called the "counter faller"—which is fixed in a similarly shaped arm fastened on the "counter faller shaft" E. By the oscillation of the shafts E F, the winding faller and counter faller are elevated or depressed, thus enabling the finished yarn to be wound into the spool or "cop" G, which is made of the shape shown. The above form the essential portions of a mule and their respective functions can now be explained.

(267) The rollers B perform the same office as those used in the drawing and roving machines, namely, the attenuation and delivery of the roving. Each of the three lines revolve at different velocities, that of the front line being the superior one, with the result that roving which, as was shown, has been already considerably reduced in diameter is still further attenuated prior to being twisted.

(268) The roving is wrapped round the spindle two or three times in commencing operations, being sometimes rendered adhesive by paste, and sometimes wrapped on a paper tube placed on the spindle. Being thus held at one end by the spindle, and at the other by the nip of the front rollers, the rotation of the former will necessarily further twist the partially twisted roving. On the degree of twist—that is the number of turns per inch—depends the amount of roving delivered by the rollers in a given time, as explained in paragraph 234.

(269) In the roving machines the relative positions of the spindle and front rollers are fixed, but in the mule an important variation in this practice occurs. The carriage I receives by suitably arranged mechanism an alternate movement from and towards the roller B. During the period they are delivering roving it is drawn away from them until it has travelled about 63 inches, when its motion ceases. While this traverse is taking place the spindles are revolving, and twist is therefore being introduced into the roving. The cessation of the motion of the carriage is accompanied by a similar stoppage of the rollers and spindles, and there is then a number of lengths of yarn—each 63 inches—held in tension by them. This traverse of the carriage is called its "stretch" or "draw."

(270) The yarn, as thus spun, requires winding upon the spindle, so as to form the cop, but before doing this it is necessary to free two or three turns which are wrapped on the spindle between its point and the point or "nose" of the cop. This operation is called "backing off." In order to effect it the roller K has its motion reversed for a short time, so as to give the necessary backward rotation to the spindles. The slack yarn thus produced is taken up, first, by the ascent of the counter faller, and, second, by the descent of the winding faller. The former rises sufficiently to preserve the tension of the yarn as it is freed, and the latter is drawn down so as to assume a proper position to commence winding when the operation of backing off is completed.

(271) As soon as this stage is finished the inward traverse of the carriage I commences, an operation which is accompanied by the forward revolution of the spindles, which thus wrap or "wind" on to the cop the 63 inches of twisted yarn. The rollers during winding are, of course, stationary. By the time the carriage has again reached its innermost point the full length of yarn is wound, and during that period the faller has risen from the base of the upper cone of the cop to its nose. This ascent is a gradual one, and

causes the yarn to be wound in finely pitched spiral coils upon the cop. With the termination of the inward traverse or "run" of the carriage winding ceases, the winding faller and counter faller wires are released, and the whole of the operations begin anew.

(272) It is now possible to define the various stages in the whole process of mule spinning. These are as follows:—

First. The period during which roving is being delivered and twisted. During it, the rollers are revolving at a defined speed; the carriage is being drawn outwards at a constant rate; the spindles are revolving rapidly at a velocity definitely relative to that of the front roller. During this period the faller and counter faller are held in the position shown in Fig. 148, being quite clear of the yarn.

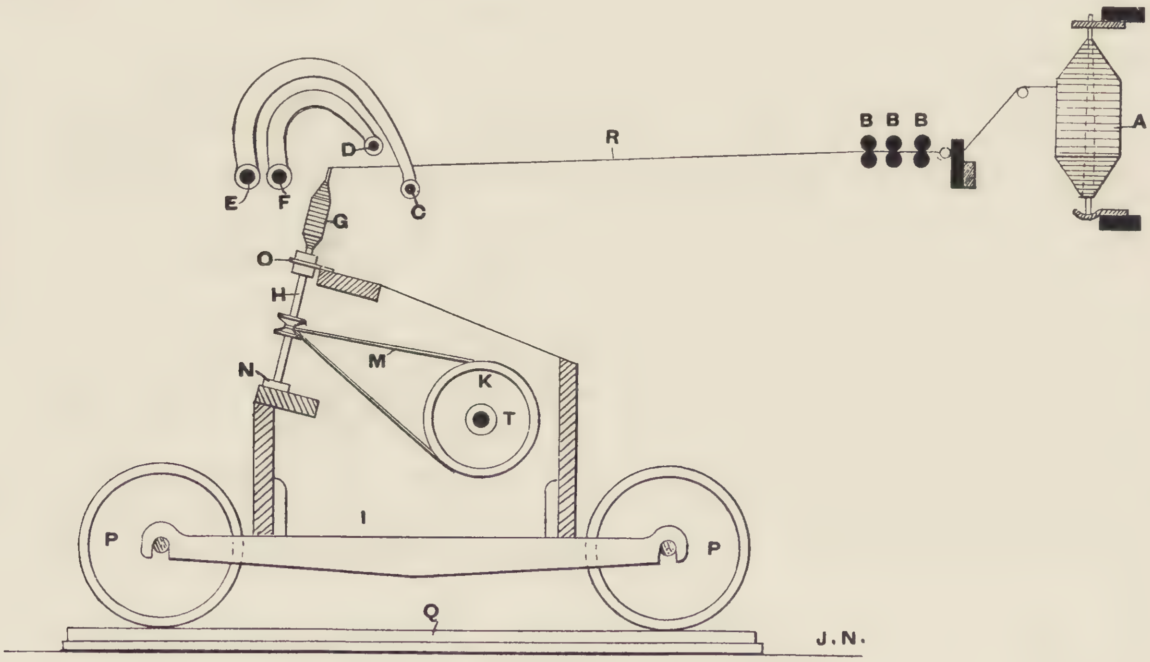


Fig. 148.

Second. The period during which the movements just named are stopped. The roller driving gear is detached; the mechanism by which the carriage is drawn out is stopped; the spindles are stopped because of the transfer of the driving strap to the loose pulley and the consequent cessation of the motion of the driving band; and preparation for the engagement of the faller and counter-faller with the yarn takes place.

Third. This is the period of "backing-off." During it the driving band is driven in the contrary direction to its normal one, and the spindles are reversed. The faller wire is drawn down, depressing the yarn; the yarn between the nose of the cop and spindle point is uncoiled; the counter faller rises and takes up the lack yarn; and the faller is "locked."

Fourth. During this period "winding" takes place. The rollers are stationary; the carriage is "running in" at a variable speed; the spindles are revolving in the same direction as when twisting; and the winding faller is operated so as to guide the yarn on the cop.

Fifth. The carriage comes to rest; the faller and counter faller are released; the roller driving gear is re-engaged; the strap is moved on to the fast pulley and the driving band put in motion; and the drawing out gear is again engaged.

With this the cycle of movements is completed, and the whole of the operations begin anew.

(273) There are thus five periods, viz., 1st, twisting; 2nd, arrestation; 3rd, backing-off; 4th, winding; and 5th, re-engagement. In addition to these, when fine yarns are spun, there is sometimes a sixth period, which takes place immediately after the termination of the first as at present defined. This is a period of supplementary twisting after the rollers have stopped. This operation is sometimes known as "twisting at the head," and will be dealt with at a later stage.

(274) It is thus indicated that at various times one part of the mechanism performs different functions. The rollers revolve for the whole or part of the first period and remain stationary afterwards. The spindles revolve at a constant and maximum velocity in their normal direction during the first period, at a slower but constant velocity in the reverse direction during the third period, and at a variable speed in their normal direction during the fourth stage. The carriage makes its outward run at a regular speed during the first period, is at rest during the second and third, and makes its inward traverse at a variable speed during the fourth. The winding faller remains stationary and free from contact with the yarn until the third period, when it makes a rapid descent to the winding point, after which it first descends quickly to its lowest point, and then ascends slowly to the nose of the cop during the fourth. The counter faller remains below and out of contact with the thread during the first and second periods, and ascends during the third, remaining in contact with and sustaining the yarn until the termination of the fourth.

(275) This preliminary explanation will enable the detailed description following to be more easily understood and appreciated. As there are many variations in the construction of the mule it is desirable to select one of the most widely used, and for this reason the machine constructed by Messrs. Platt Brothers and Co. has been chosen for description. Front and back perspective views of the machine are given in Figs. 149 and 150. The Parr-Curtis mule is also largely employed, and many modifications of it exist. All the root principles which are contained in the machine are, however, found in the Platt machine. That is to say, it contains mechanism founded upon certain rules which are essential to all mules, so that, although the details may be, and are, varied, the main features are identical. A detailed description of its mechanism, therefore, will enable the subject to be fully understood, but, at the close of the chapter, particulars will be given of special features in other makers' machines. To enable the construction of the machine to be more fully grasped, a series of diagrammatic views are given of each motion separately, and the reference letters are arranged so that each part is marked with the same letter in all the views in which it occurs, although the same letter, in some cases, refers to various parts in different diagrams.

(276) It may be first explained that the greater number of the parts by means of which the required motion is given to the various portions of the mechanism are contained in a longitudinal framing placed in the centre of the machine, this part of the mule being called the "headstock." At right angles to the headstock, and at each side of it, the rollers and carriages extend for the entire length of the machine. The arrangement of a "pair" of mules is clearly shown in Fig. 151, the machines being usually placed with their headstocks zig-zag to one another. The carriage of one mule is coming out while that of the one opposite to it is at the roller beam, this arrangement permitting the free movement of the workman attending to the machines, and preventing the broken threads in each machine requiring piecing at the same time. It might, perhaps, be explained that "piecing" is always effected when the carriage is making the first part of the outward run, so that some inconvenience would arise if both carriages were in that position at the same time. A special motion is sometimes fitted by which each carriage is released alternately by the movement of the carriage opposite to it. Referring now to Fig. 151, H represents the

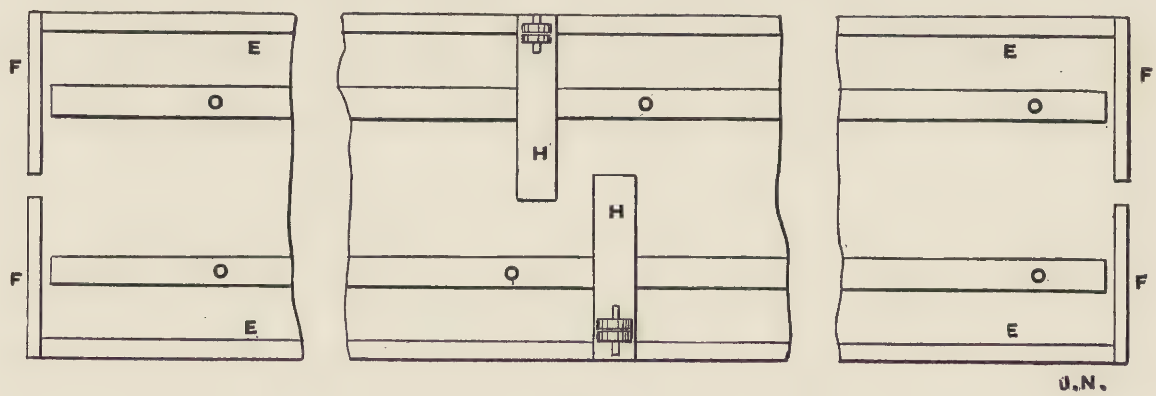


Fig. 151.

headstocks of the two mules, E the lines of rollers, F the end frames, and O the carriages. It will be noticed that the headstock divides the machine into two portions of unequal length, each of which contains its own rollers and spindles. The special object of this is to enable the mules to be placed in closer proximity than could be done if both sides were of the same length, and the headstocks were placed quite opposite to each other.

(277) The rollers are in three lines, and are borne in brackets or stands fastened to longitudinal iron "roller beams," sustained at intervals by light frames or "spring pieces." The lower lines of rollers are finely fluted, and are made of the same superior quality of iron as those used in the roving frames. Their diameter is usually an inch, but this varies with the staple to be spun. The front line of top rollers are generally of Leigh's loose boss type, cloth and leather covered, and are weighted by a saddle, stirrup, and lever weight. The middle and back lines are "common rollers," also covered in the same manner. The front lines of the right and left-hand set in each mule are coupled by a short shaft, and the second and third are driven from the first.

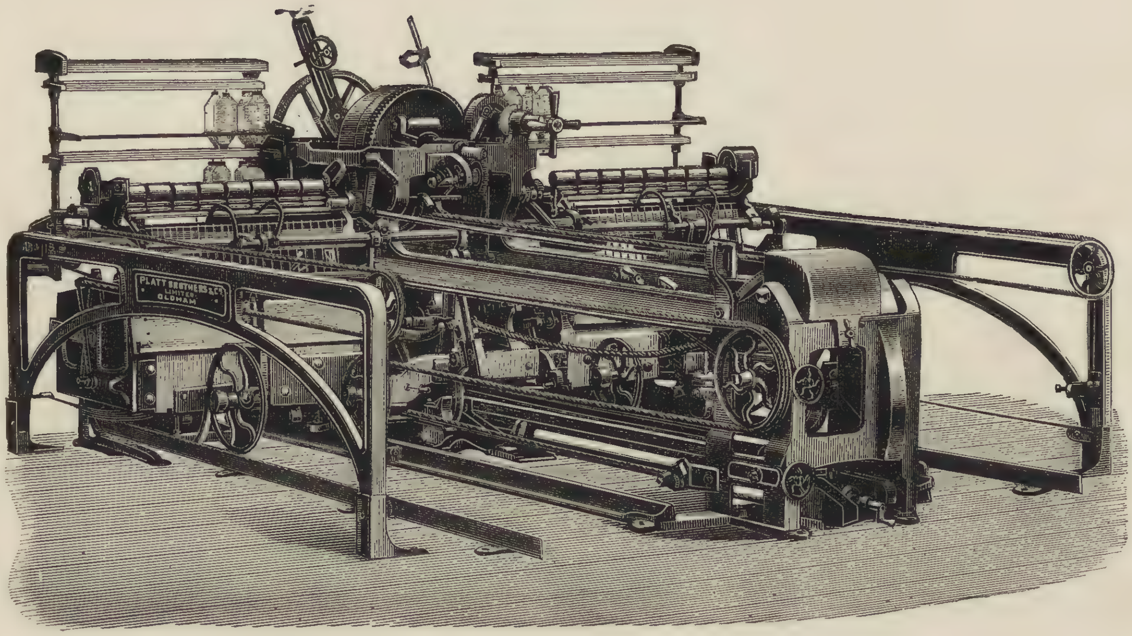


Fig. 149.

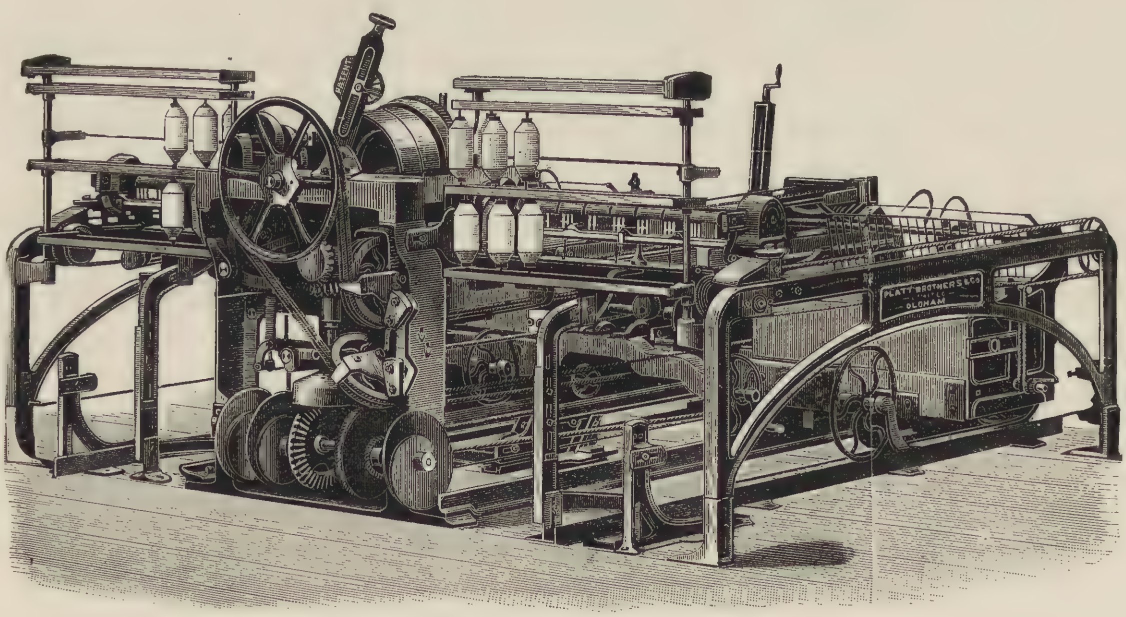


Fig. 150.

(278) The carriage has a rectangular frame, being built with strong longitudinal timbers, securely tied together by cross pieces. These carry, as was shown, the bolster and footstep rails. On the cross cast-iron "muntins" the bearings for the tinroller shafts are fastened. The carriages at each side of the headstock are coupled by a strong iron frame, to which they are securely fastened. This is known as the "square," and carries some of the mechanism for giving motion to the spindles and building the cop.

(279) The tin roller is generally six inches in diameter, and consists of a series of cylinders made from sheets of tinned iron, securely soldered together. In each end of the rollers so formed an iron disc is fastened, and the lengths are coupled by means of short shafts. The whole of the lengths are thus connected, and a bearing is placed at each junction, so that the tin roller is well sustained throughout. The rollers in each of the two carriages are coupled by a short shaft, extending across the square, and carried by means of pedestals, fixed to the latter. On this short length of shaft the driven tin roller pulley is secured, as will be hereafter fully described.

(280) The spindle is made of steel, and is from $13\frac{1}{2}$ to 18 inches long, according to the class of material being dealt with. For coarse counts and for "twist" yarn a larger cop is made, and the spindle is of necessity longer. For 32's twist yarn a spindle about 17 inches long is used, and its diameter varies from $\frac{3}{8}$ths inch to less than $\frac{1}{8}$th inch. The part between the two bearings is called the "haft," and that above the bolster—on which the cop is wound—the "blade." The spindle is thickest in the haft, terminating in a small foot, but the blade is tapered throughout. Great care is taken with the spindles to ensure their accuracy, and they can, therefore, be run at velocities as high as 11,000 revolutions per minute without vibration. The extra diameter of the haft ensures the necessary resistance to flexure caused by the pull of the driving band. The latter is a thin cotton cord—made of the best grades of cotton—passed tightly over the spindle warve and the tin roller. It is highly important that the bands should not be either too tight or too slack. In the one case the friction generated would be excessive and detrimental, and in the other the twist would not be fully put into the roving, which would be said to be "slack twisted." Varying atmospheric conditions materially alter the tension of the bands, and their proper piecing is only to be mastered after long practice. The spindle is disposed in the carriage at a varying angle, to suit the material being spun.

(281) The description of the general construction of the machine thus given clears the ground for the detailed explanation which follows. For convenience it will be as well to begin by describing the mode of obtaining the motion of the spindles. This is illustrated in Fig. 152, which is a diagrammatic representation of the course of the bands and driving pulleys. The mule is driven from the line shaft, or a counter shaft by means of a strap passing over the pulley A fastened upon the shaft C. The latter is termed the "rim shaft," and upon it the loose pulley B is also placed. Free to revolve and slide upon the same shaft is the spur wheel A^1, formed with a large internal cone, the exact object of which will be hereafter described. The fast pulley is about 5 inches wide, and the loose pulley $5\frac{1}{4}$ inches, the diameter being about 15 inches. Thus, when the strap is on the fast pulley it is also partially on the loose pulley, which is always revolving. At

the other extremity of the rim shaft a double, treble, or quadruple grooved pulley C^1 is fixed, which is called the "rim." Over this the endless cord or band driving the spindles is passed—being known as the "rim band"—its course being clearly shown by means of the arrows. It will be noticed that it is first passed round a carrier pulley on the carriage square, and then round the tin roller pulley on the tin roller shaft T, being then taken round the carrier pulley Y fixed at the end of the headstock frame, afterwards returning to the rim pulley. It will, of course, be understood that the explanation just given relates to the course of the rim band, considered as a single rope. When the rim is double or treble grooved, corresponding arrangements must necessarily be made in the rim band course. The rollers E are driven from the rim shaft by the train of wheels and the side shaft G shown, and the drawing out of the carriage is effected by the band passing round the scrolls at H and round the pulley Z. This will be more particularly described presently.

(282) Particular reference will now be made to Figs. 153 and 154, which are respectively longitudinal sections of the driving gear and back view of the same. The loose pulley B has formed upon its boss a spur pinion B^1, from which, by means of a carrier wheel, the side shaft D is driven. On the other end of this shaft a pinion D^1 is fixed, which gears with and constantly drives the spur wheel A^1, this being the object of the overlapping of the driving strap previously referred to. The wheel A^1 is formed, as shown, on its inner side with a large internal conical surface, which, at the proper moment, engages with a corresponding leather-covered surface formed on the pulley A. This engagement takes place for the purpose of backing-off, and the cone A^1 is therefore known as the "backing-off cone" or "friction." The engagement of the friction cone with the fast pulley causes it first to act as a brake, and the strap having been moved upon the loose pulley it then exerts sufficient force to revolve the backing-off cone in the contrary direction. To enable this contact to take place a ring groove is formed in the boss of the backing-off wheel, in which a claw engages, which is oscillated as afterwards described. The effect of this arrangement is that the rotation from the loose pulley B of the friction wheel A^1, whilst it is engaged with the fast pulley A, causes the rim shaft to be rotated in the opposite direction to that normal to it. The direction in which the various parts revolve normally is clearly shown by the arrows. The extent of the backward movement of the rim shaft depends, of course, entirely upon the length of time during which the friction cone A^1 is allowed to engage with that on the pulley A, this being regulated by the amount of yarn to be unwound.

(283) The rollers E are driven from a pinion G^1 fastened on the rim shaft, by means of which the shaft G is revolved, and motion is thus given to a bevel wheel loose upon the short shaft coupling the two front lines of rollers. One half of a toothed or claw clutch is formed on the boss of the wheel, the other half of which is secured to but slides upon the coupling shaft, being formed with a ring groove on its boss into which the two arms of a claw are fitted so as to engage and disengage the clutch.

(284) On the boss of the bevel wheel is a spur wheel which, by means of the train of wheels shown, communicates the forward movement to the "back" shaft H on which are fixed the scrolls H^1. On these the ropes or bands shown are wound, being attached to the carriage as shown in Fig. 152. As

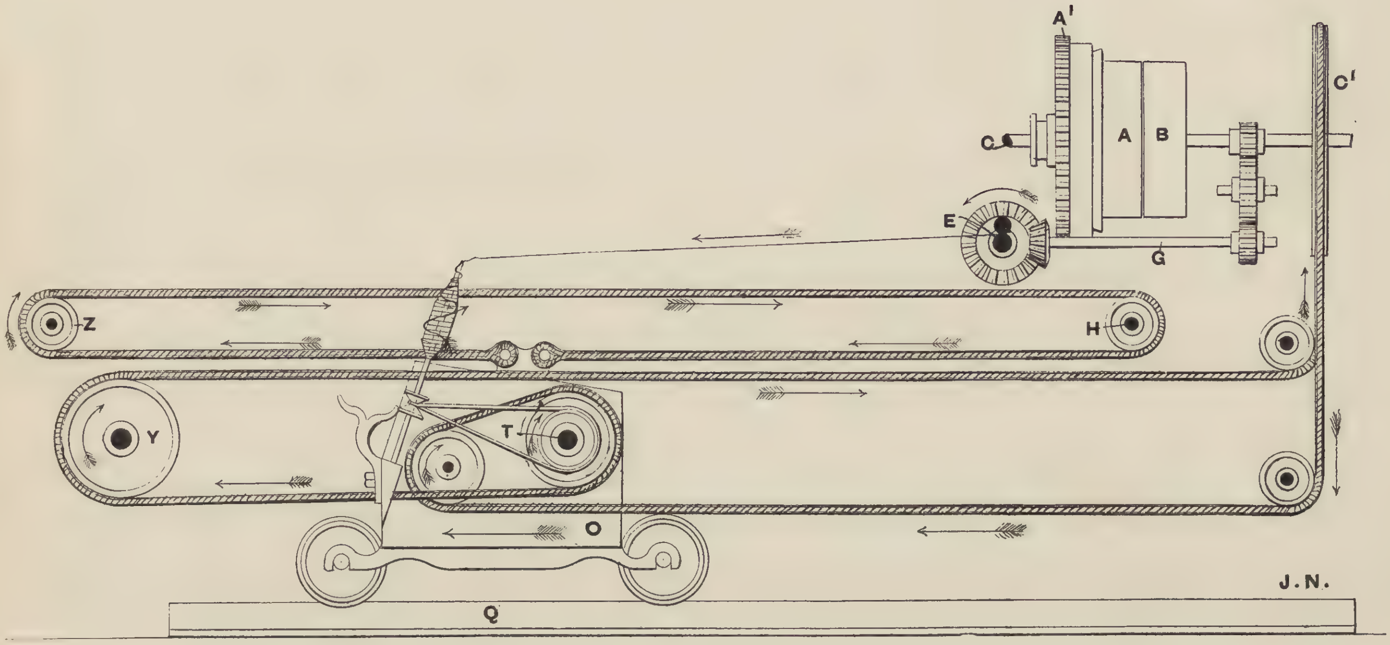


FIG. 152.

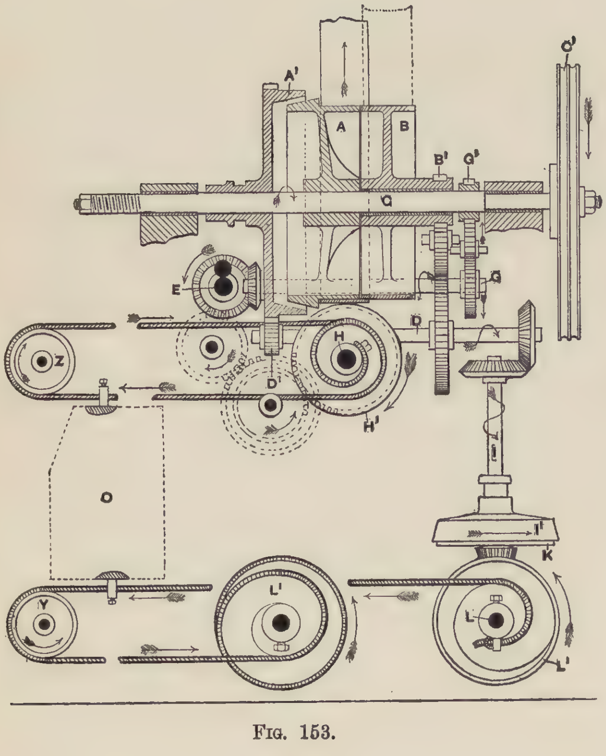


FIG. 153.

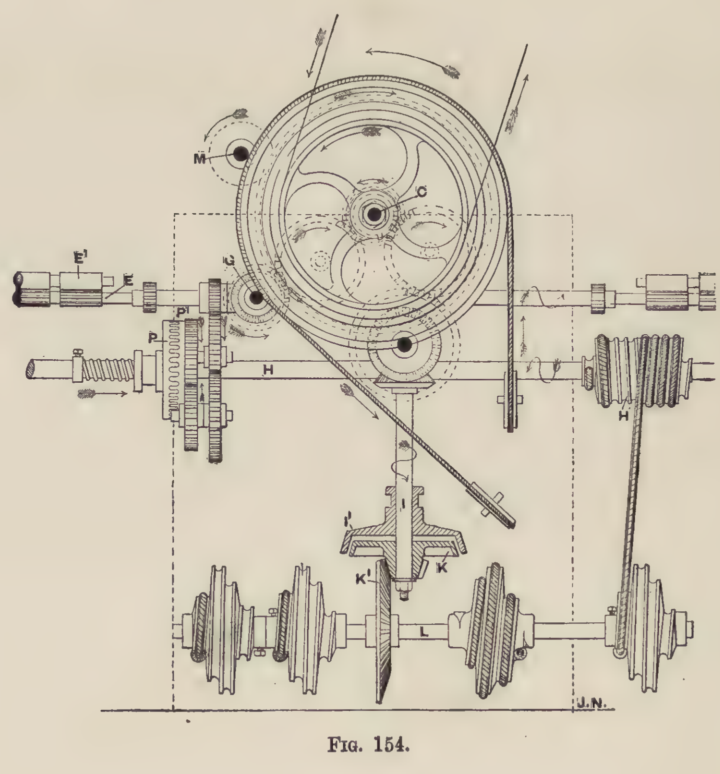


FIG. 154.

the carriage extends to the right and left of the headstock, as explained, the back shaft H is similarly extended, and has placed upon it a number of scrolls at suitable distances apart, on which other bands are wound. This enables the carriage to be evenly drawn out throughout its entire length. The method of attaching the bands to the end frames of the carriage is shown in Fig. 155, and it will be seen that there is power of adjustment given, which enables the carriage to be "squared" or kept parallel with the roller beam. The last of the train of wheels P^1, by which the back shaft is driven, is loose upon it, and forms one half of a clutch, the teeth of which are peculiarly shaped. The other half P slides upon the boss of a disc which is keyed upon the shaft, and has a ring groove in its boss, being ordinarily pushed up to its position by a spiral spring surrounding the back shaft and kept in compression by a stop hoop or collar which can be set up as desired. This, combined with the peculiar construction of the teeth, enables the clutch to open and its teeth to glide over one another in the event of any obstruction being offered to the free outward run of the carriage. The forked end of an L lever fits in the groove in the clutch, being oscillated as afterwards described.

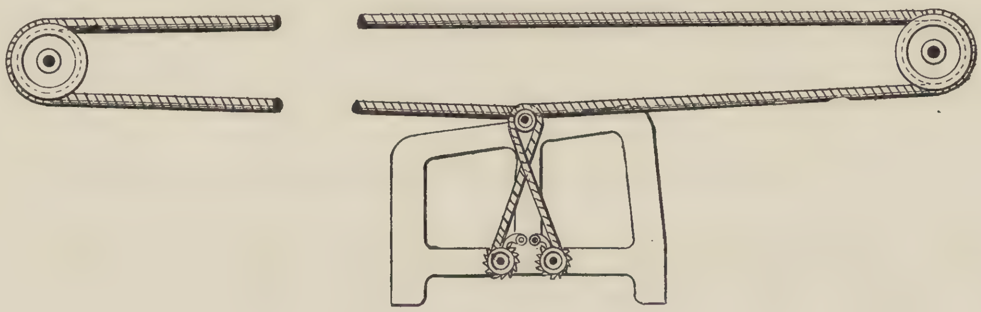


Fig. 155.

(285) The bevel wheel on the outer end of the taking-in side shaft D gears with a similar one fixed on the upper end of the vertical shaft I, on the lower end of which is loosely placed the friction cone K. With the latter the hollow cone I^1 engages, this being able to slide in a vertical direction on a disc keyed to the shaft. It is usually kept out of gear by means of a hinged forked lever, the fork of which fits in the groove shown in I^1, and which is sustained at its free end so that it can be readily released to allow the sudden engagement of the friction cone. On the half cone K, at its underside, is cast a small bevel pinion, which engages with a bevel wheel K^1 fixed on the shaft L, extending transversely of the headstock at the back. Spirally grooved or "scroll" pulleys L^1 are fixed on the shaft L, on which ropes are wound, these being attached to the carriage square as shown in Fig. 168, page 212. An additional scroll is fitted on the shaft L, and is set at such an angle that when the rope is fully drawn off the other scrolls it is wound on the additional one. When the friction cone is in gear the ropes are wound on to the scrolls, and the carriage is drawn in. From the fact that these scrolls are employed, and that their object is to draw in the carriage, the shaft L is called the "scroll" or

"taking-in" shaft, and the friction cone is commonly styled the "taking-in friction," or, more shortly, the "friction."

(286) The means just described are those which are in use on a large number of mules constructed by Messrs. Platt, and worked satisfactorily until the speed of the rim shaft was largely increased. Up to about 750 revolutions the train of gearing driving the taking-in side shaft could be used, but as the rim is now run at speeds as high as 900 revolutions it is the practice to drive the taking-in side shaft by means of a grooved pulley fastened upon it, and driven by a separate band from the counter shaft. In this way much of the strain is taken from the rim shaft, and the use of gearing obviated for the taking-in and backing-off. When this method is adopted—as is now almost generally done—there are many advantages gained, and it is the most modern practice.

(287) Another method of driving, also largely employed by Messrs. Platt, is a patented system of duplex driving. This is shown in plan in Fig. 157. Instead of using one belt only, by means of which the power is transmitted, two narrower ones are employed, each of which is $2\frac{3}{4}$ inches wide. The fast pulleys A are also $2\frac{3}{4}$ inches on their face, while the loose pulleys B are 3 inches wide. The strap guide is made, as shown, double, and the distance which it has to traverse is only half that which is usual. The advantages of this arrangement are derived both from the smaller width of the belts, and the shorter distance they need moving. The diminished width causes the belt to be more pliable and less rigid, and in consequence the pressure applied is more readily responded to. The shortened traverse enables the change of the belts to be made more easily and in less time, and, in consequence of the latter fact, the time the edges of the belts are pressed upon by the guider is reduced. This reduction involves considerably less wear of the strap edges, which, alike on this account and because of their easier and less strained motion, are found to have a much longer life. The smooth action of the belts produces another effect. It enables the full speed of the rim shaft to be more readily reached, and so tends to increase the production of the machine. The makers have now constructed a large number of mules with this arrangement, and its use is steadily extending.

(288) The mechanism just described is that on which depends the driving of the whole of the parts, and its mode of action can now be easily explained. Beginning with the commencement of the outward run, when the rim band is traversing in its normal direction, the rollers commencing to deliver yarn, and the spindles revolving, the position of the parts is as follows. The strap is on the fast pulley, and the rim shaft is revolving. The backing-off friction is out of gear, the necessary motion is given to the roller shaft, and as the claw clutch is engaged the front line of rollers is revolved, roving being delivered. At the same time the back shaft is driven, the clutch on it being in gear, and the carriage is drawn out. The scrolls on the back shaft are shaped so as to allow the carriage to move at a constant velocity. While the carriage is running out the rim band is giving the required revolution to the tin roller shaft, and the spindles rotate in consequence at their normal velocity. The carrier pulley on the square shown in Fig. 152 is arranged at such an angle that the rim band passes freely on to and from the pulley on the tin roller shaft. A similarly accurate setting is given to the guide pulleys

at the back of the headstock, the wear of the bands being much reduced in consequence. The velocity given to the carriage is slightly in excess of that of the surface speed of the rollers, so that the roving is a little stretched. The excess of the carriage traverse is from 1 to 3 inches, and is known as its "gain."

(289) When the carriage reaches the termination of its outward run, or, as is commonly said, the end of its stretch, it becomes necessary, first to arrest and then to reverse its movement, these operations necessitating a complete change in the positions of the various parts. The chief agent in making these changes is the shaft M, placed parallel to but a little higher than the rim shaft. It is known as the "cam shaft," and plays an important part in the operation of the machine. It is entirely distinct both by position and function from the rest of the mechanism, and a separate view of it and its connections is given in Fig. 156, which is a detached sectional elevation.

(290) Hinged to one side of the headstock framing is the lever T—known as the "long lever"—at each end of which pins are fastened, which carry the bowls R R^1. Fastened to the carriage by bolts are two horn brackets S S^1, to which power of adjustment is given. The underside of the brackets is curved, and they are fixed at such a height, that, as the carriage approaches either end of its run, one of them will engage with the bowl or runner carried on a stud fixed in the end of the long lever, as shown very clearly by the dotted lines. At the outer end of the long lever, the bell crank lever Q is pivoted, and is ordinarily drawn towards the end of the long lever by a spiral spring O. In this way, when the latter has assumed a position in consequence of the pressure of the horn brackets S S^1, the pressure of Q upon it prevents it from moving until a similar force is again applied. In short, the long lever is locked.

(291) On the cam shaft three cam or eccentric surfaces are placed, marked respectively W Y and Z. These are shown with their connections in detached views. The cam W is compounded with the male half of the friction clutch X, and can slide along with the half clutch upon a feather key fixed in the shaft. The other half of the clutch is loose upon the shaft, and has formed upon its boss a spur pinion which, as shown in Fig. 153, engages with the teeth of the backing-off wheel A^1. Thus the continuous rotation of the latter leads to a similar movement of X, and, as a consequence, the latter is always in a state of readiness to rotate the cam shaft. A spiral spring surrounds the cam shaft, being sunk into a recess in the bearing and continually pressing upon a flange formed on the sliding half of the friction clutch, thus tending to force the latter into gear. On the inner side of the flange two cam surfaces are formed, as shown at V, with which the nose of the rocking or escape lever engages. The latter is connected by a short rod to the end of the long lever, the whole attachment being very clearly indicated in the illustration. Suppose the end of the lever to be in the position shown in the left hand view of V, the friction clutch would then be engaged, and the cam shaft would revolve until the outer cam surface on V came into contact with the end of the lever, when the sliding half clutch would be disengaged and arrested, and the motion of the cam shaft would cease. In this position the parts remain until the long lever is again moved, this time having its inner end depressed by reason of the contact of the bracket S^1, and bowl R^1. The nose of the escape lever is then moved off the outer cam surface into the flat or level portion of the inner

cam course. This permits the re-engagement of the friction clutch, and the cam shaft makes the second half turn, causing the inner cam course to engage with the nose of the lever and again disengaging the friction clutch. The raised cam surfaces on V are directly opposite one another, so that the cam shaft can only make a half turn before it is disengaged. The next movement of the long lever, which takes place at the end of the next outward run, is caused by the engagement of S and R, and the escape lever nose is then moved on to the level surface of the outer cam course. This alternate movement of the long lever takes place, as will be readily understood, when the carriage reaches the termination of its inward and outward runs.

(292) If it be assumed that the carriage has reached the end of its outward run, and the cam shaft has made a half revolution, three things take place. The back shaft clutch is disengaged, and the shaft ceases to revolve; the roller clutch is detached, stopping the delivery of roving; and the cam Y is moved into such a position that the strap lever can traverse so as to allow the strap to pass on to the loose pulley.

(293) The back shaft clutch is controlled by the internal cam Z, in which a bowl on a pin fixed in the bell crank lever Z^1, Fig. 162, page 201, to which reference will be made for this part of the subject, works. In the groove of the sliding half P of the clutch, the forked end of the lever T fits, this lever being hinged at its lower end and having a horizontal arm, the end or nose of which rests upon the horizontal limb of the rocking lever Z^1. Thus, when the latter is rocked so as to make an upward movement, the lever T is raised, and causes a disengagement of the clutch P P^1. The back shaft is thus freed, and all motion of the carriage ceases.

(294) The rollers are disengaged by the cam W, which acts upon the cranked lever shown, the vertical arm of which is forked and fits in the groove in the loose half of the roller clutch I. When the cam is in the position shown in Fig. 156, the rollers are engaged, but when the cam shaft makes its half revolution the lever is oscillated and the clutch is detached. As previously noted, the cam course is formed in the loose half of the friction clutch X, which thus serves a double purpose.

(295) The compound strap guide lever is placed almost vertically, as shown in Fig. 158, being hinged upon a pin in the headstock frame. The part G carries a short pin on which a small runner or bowl can freely revolve. While the carriage is running out, the bowl is at the point of the cam Y, but when the half revolution of the cam shaft is made it assumes a position at the base of the cam. These two positions are very clearly shown in the right hand bottom corner of Fig. 156. This allows the strap to move, in a manner more particularly described afterwards, on to the loose pulley, so that the backing off friction can be engaged.

(296) It has thus been shown that the half revolution of the cam shaft causes the stoppage of the motion of the carriage, rollers, and spindles. This is the second stage or period, and it is at once followed by the third. Before passing on it is worth while reiterating that there is a decided advantage in the constant rotation of the loose half of the clutches X and A^1, their engagement being made more rapidly and with less

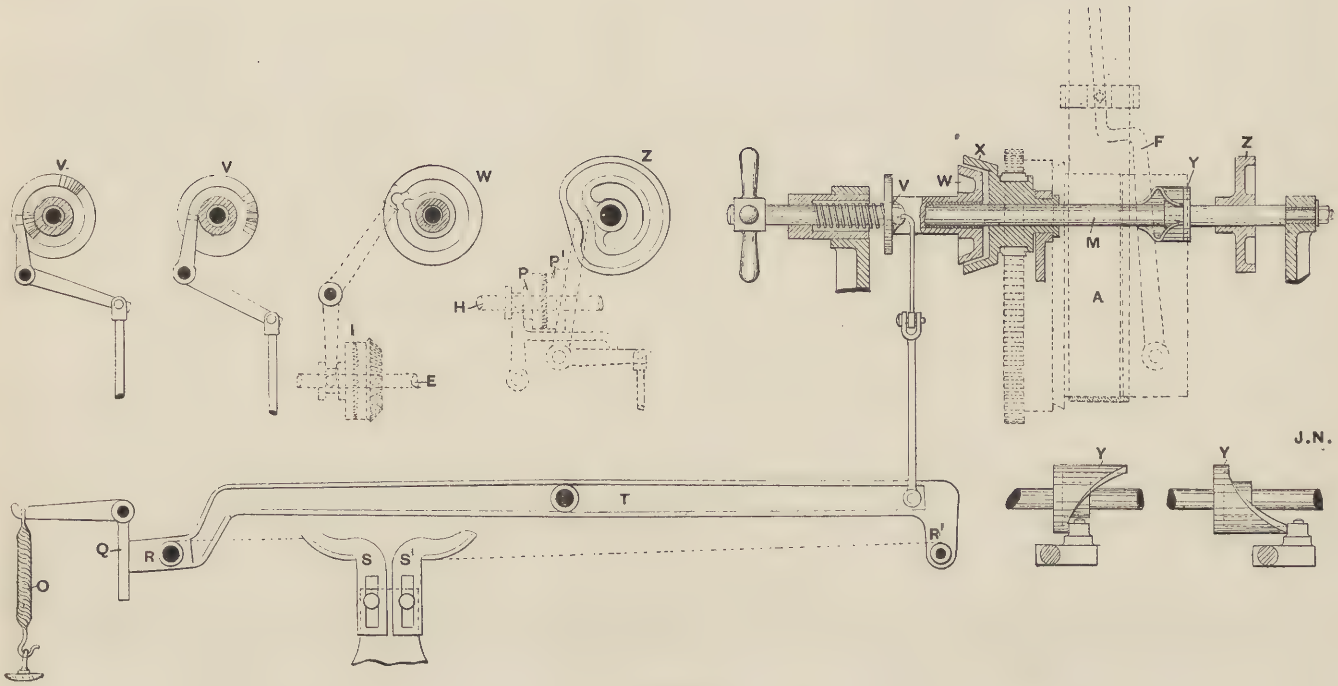


Fig. 156.

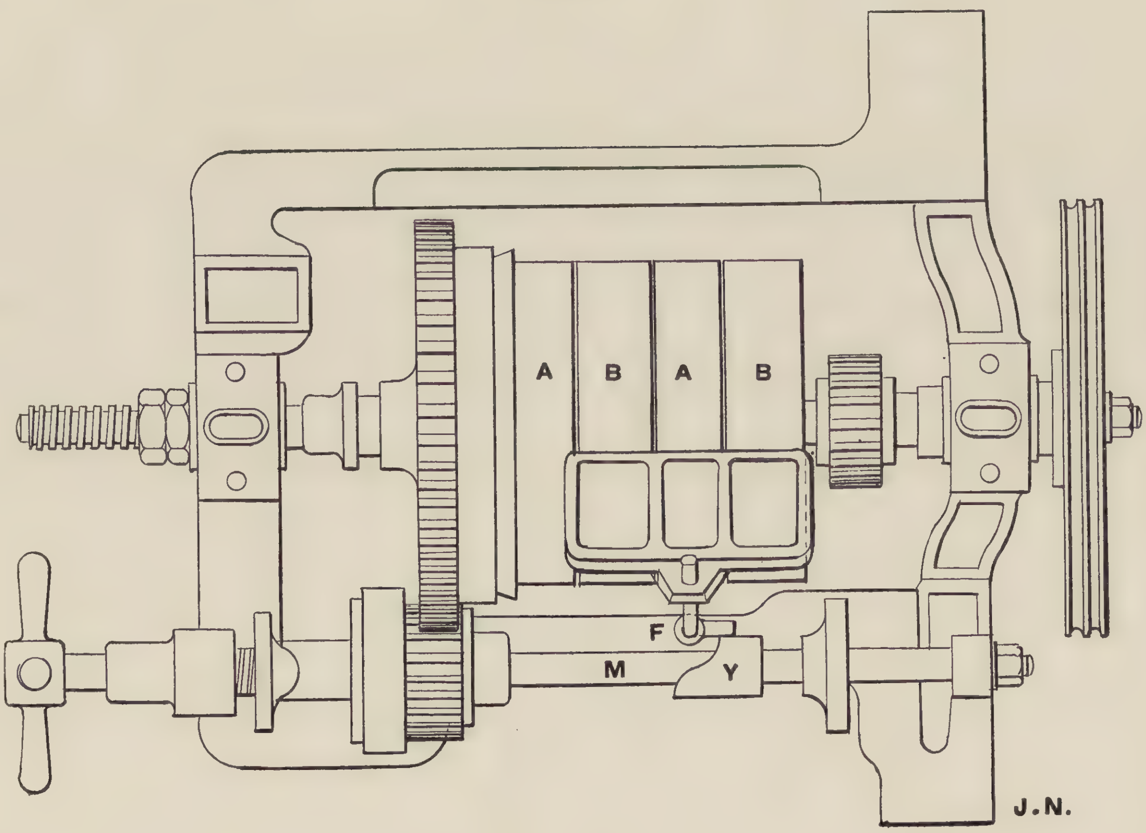


Fig. 157.

strain. The power derived from the portion of the strap upon the loose pulley is sufficient to rotate the cam shaft, and cause it to make the changes. It is also capable of maintaining the steady rotation of the backing-off and taking-in friction clutches, so long as these are not in gear, or communicating motion to the spindles or carriages.

(297) The strap guide arrangement is shown in detail in Fig. 158. The guider is fixed at the upper end of a lever F, which is hinged, as shown, at its lower end to the heel of the lever G. F has also an arm F^1, which is coupled to a horizontal limb of the lever G by the spring S. The two or compound levers are therefore constantly drawn towards each other. The lever G is secured on a short shaft, and has a second spring Q attached, which pulls it in the direction of the arrow, when it is freed by the rotation of the cam Y. A short stud bowl is fixed in G, and the pull of the spring presses it constantly against the cam. Coupled to a short arm, fixed on the shaft to which G is secured, but at the other side of the headstock, is the horizontal lever H, the outer end of which is drawn upwards by the spring P, fastened to the framing. A shoulder or recess is formed in H, which ordinarily engages with the fixed catch L, by which the strap guide lever is locked in position when the strap is on the fast pulley. On the inner end of the rim shaft a worm K is formed, which gears with a worm wheel compounded with a spur pinion, which, in turn, gears with the spur wheel shown. On the spindle of the last-named wheel a small crank O is keyed, the outer end of which has a pin, carrying a bowl, fixed in it.

(298) The action of this mechanism is as follows: The revolution of the rim shaft causes the crank O, which is, at the commencement of the outward run, just clear of the nose of the lever H, to revolve. By the time the outward run is completed, the crank will have made almost a complete revolution. When the necessary twist has been put in the yarn, the crank O comes in contact with the front end of the lever H and releases the catch L. Immediately this happens the spring Q acts, and the strap guide lever oscillates, causing the strap to glide upon the loose pulley.

(299) This step having been accomplished, the next operation is to engage the backing-off friction. As shown in Fig. 158, the boss of the wheel A^1 is formed with a ring groove, into which a claw fastened on a short stud fits. The lever D is also fixed on the same stud, so that any movement given to it is communicated to the claw and backing-off friction. The lower end of the lever is forked and passes over a rod X extending along the side of the headstock. This rod is guided by a bracket fixed to the side of the frame, and has the two stop hoops X^1 X^2 fastened on it. Between the stop hoops a spiral spring, always in compression, is threaded upon the shaft, one end pressing against the lever D, and the other against the hoop X^2. It will be readily understood that the compression of the spring will tend to push the lever D in the direction of the arrow, until its motion is stopped by a link connected with the slide in the arm, to which is fastened the lever H. It is essential that the engagement of the backing-off clutch should be practically simultaneous with the transferring of the strap from the fast to the loose pulley, and it is therefore desirable that the spring on X should be put in compression a little before the actual traverse of the strap.

(300) This is accomplished by means of the swinging lever V shown in Fig. 162. This is hinged upon the square, and is formed, as shown, with an open mouth, at the upper part of which is an angular projection

or lip. Pivoted on the framing is the lever L, the horizontal arm of which carries a small runner, which engages with the incline of V as the carriage runs out. The lever V cannot, until the termination of the stretch, be swung upon its pivot by reason of its connection with the faller locking lever A. When, therefore, the bowl in the lever L engages with the incline of V, the lever L is oscillated, so that the spring on X is further compressed. The spring is, therefore, in a position to push the backing-off lever forward, as soon as the latter is freed. The engagement of the lever L with the lever V takes place a few inches before the carriage arrives at the end of its outward run.

(301) When the outward run is completed, and the cam shaft begins to revolve, the lever D has sufficient pressure on it to push it over if it were free to move. Reverting again to Fig. 158, the horizontal lever H and the arm previously referred to are coupled by a small pin in the latter, which takes into a slot in the former. When, therefore, the lever H is locked, the vertical lever D cannot move, but when the unlocking of the lever H by the crank O occurs, the oscillation of the strap lever draws, by means of the arm, the lever H in the direction of the arrow. This permits the spring X to extend and push the lever D forward and so engage the backing-off friction. This movement is rapid and nearly simultaneous with the transferal of the driving strap. The mechanism is set to permit the backing-off friction to come gradually into gear for the purpose of acting as a brake, as was explained in paragraph 282.

(302) The friction cones being engaged and the strap placed on the loose pulley, the rim shaft is driven in the contrary direction, thus reversing the spindles. It therefore becomes necessary to take up the yarn as it is delivered from the spindles. This is effected by means of the faller and counter faller, as indicated in paragraph 270, and the precise mode of action of these can now be described.

(303) The faller arms M and U, as shown in Fig. 161 (page 205), are sickle or crescent shaped, so that they can readily pass down between the cops without touching them. The arms are keyed on the winding faller and counter faller rods B B^1 at convenient intervals, and the wires are threaded through them. The latter are thus well sustained, and do not deflect to any appreciable extent, this being fatal to the effective building of the complete set of cops. The rods or shafts B B^1 are borne by brackets fastened to the carriage, so that their axes are quite parallel to the centre line of the carriage. The winding faller shaft is oscillated by suitable mechanism, by which at the proper moment it is drawn downwards, while the upward movement of the counter faller is regulated from the winding faller. There is an important difference in the action of these parts. As the winding faller is to act as a guide to the yarn during winding, it is essential that it is, at the beginning of each inward run, in the correct initial position for that purpose, and that, when it has reached that position, it shall be locked. On the other hand, the function of the counter faller being merely to maintain the tension of the yarn during winding and backing-off, it is necessary that it should be free, so as to bear constantly against the underside of the threads without exercising an undue strain. The pressure thus exerted should be a little in excess of the downward pull of the whole of the threads which are being spun in the machine, but not so much in excess as to prevent the counter faller yielding a little if from any cause an extra pull is put upon the threads. In other words, the action of the winding faller is positive, while the counter faller acts as a

regulator of the yarn tension. In order to maintain this relation t is desirable to establish a connection between the descent of the faller and the ascent of the counter faller. This is done by making the latter dependent on the former, and by leaving it free after it has been released.

(304) The controlling mechanism is shown in Fig. 159, which is a representation of the parts affecting the counter faller. Hinged, as shown, to a bracket on the underside of the carriage is a lever J, to which are attached two chains E^1 I. The former is coupled to a sector E, which is secured on the counter faller

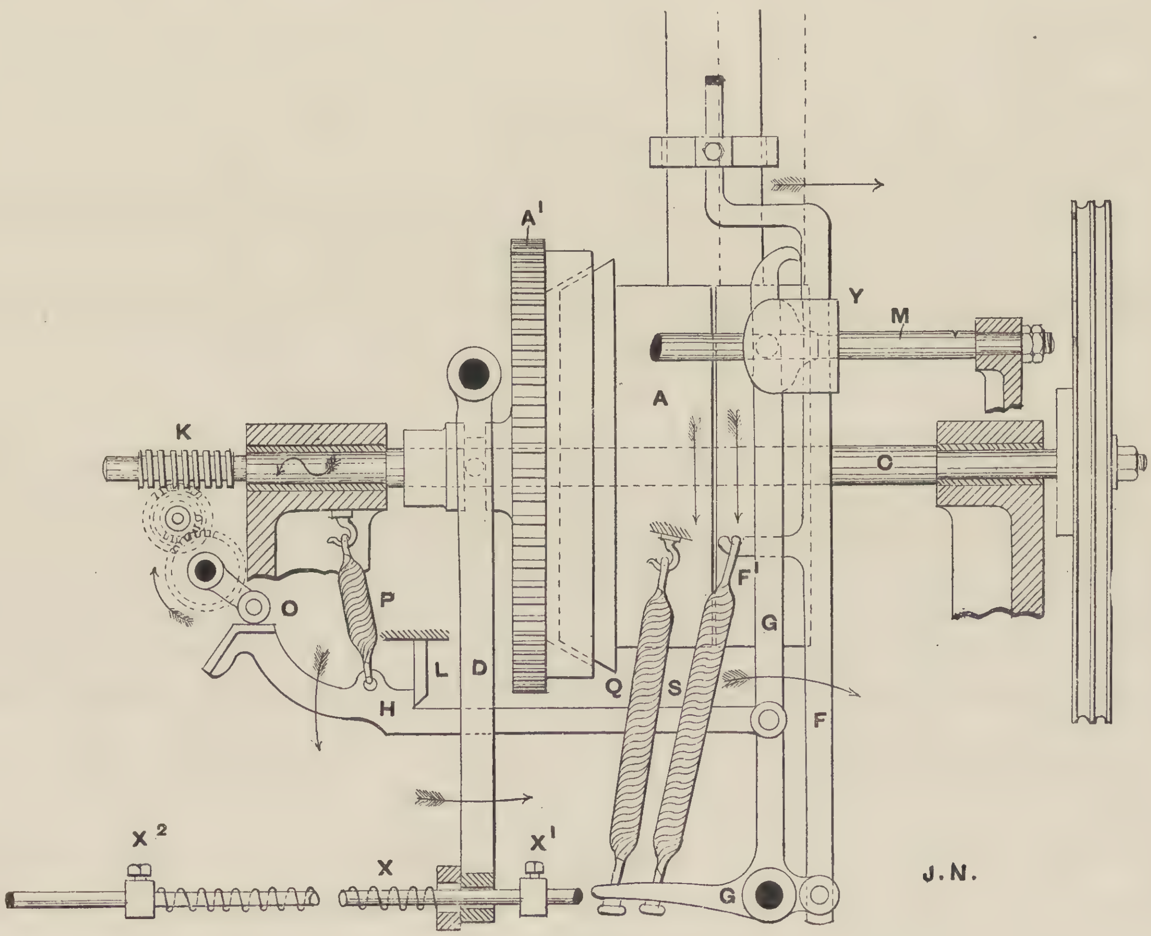


Fig. 158.

shaft or rod B^1. If it is assumed that the latter is free to rotate, as it is, the pull exercised by the lever J would be sufficient to cause it to do so. But until the winding faller makes its descent so as to assume the winding position, as afterwards described, the weight of the lever J is taken by the chain I, which at its upper end is fixed to the hook shown. The latter is hinged to the bracket or lever S, the other arm of which rests upon the counter faller rod B^1, and thus limits the upward movement of the winding faller.

A steady torsional pull is exercised upon the bracket S, so as to draw the chain I upwards, by the spring V, attached as shown. The unwinding of the two or three coils of yarn during backing-off takes place during the time the winding faller is descending. Immediately backing-off is completed, the carriage begins to run in, and the yarn is wound. It is therefore necessary for the counter faller to rise, so as to take up any slack yarn. Unless this is done, the yarn—owing to its tightly twisted condition—runs into small loops or kinks, technically known as "snarls." The oscillation of the winding faller rod B has caused a similar movement in S, and, as a result, the chain I becomes slackened and ceases to sustain the lever J. As, therefore, the carriage O begins to run in the lever J descends, and the whole of its weight is borne by the chain E^1, which is caused to pull upon the sector E. In this way the counter faller rod B^1 is oscillated, and the counter faller wire M is raised. The extent of its upward movement is regulated solely by the tension of the threads, which is sufficient to act as a counterbalance to the lever J. In order that this equilibrium shall be sufficient to preserve the necessary tightness of the threads, without any danger existing of either slack threads or of the counter faller being unyielding when an extra strain is put upon the yarn, balance weights can be added at the end of the lever J, as shown. In this way the necessary sustainment of the yarn threads is obtained without any likelihood of straining or breakage. When the carriage has completed its inward run the weight of the lever J is relieved by the roller W, so that the faller, when released, as afterwards described, can easily assume its proper position during spinning or twisting.

(305) While the counter faller is being freed in the manner described the downward movement of the faller is also proceeding. Referring now to Fig. 160, which is a detailed view of the faller arrangement, the faller shaft has fixed on it an arm or backing-off finger D, to which is fastened one end of a chain E. One end of E passes round the small bowl F, and its other end is fastened to a snail or scroll G mounted on the tin roller shaft. The snail is geared by a ratchet clutch which engages only when the tin roller is revolving during backing-off, being disengaged during the whole period of spinning. The size of the snail is arranged so as to draw down the faller finger D during the period of backing off to such an extent that the faller is brought into the proper position for the commencement of winding. In dealing with the latter operation it will be shown that the faller is a little below the cop nose when winding begins, and then rapidly descends until the base of the upper cone is reached. At present it is only necessary to note this fact, as it has a somewhat important bearing on the mechanism being described. During the period of the faller descent a pull is exercised on the rod F^1, by which the bowl or runner F is carried. The other end of F is hinged to the "locking" lever A, to which the curved arm or sector C is hinged at its upper end. This arm is fixed on the faller shaft, so that the oscillation of the latter, which is caused by the pull of the chain E, gradually raises the "locking" lever A. This elevation goes on until the shoulder or bracket K is high enough for its under side to slip over the small bowl fixed in the lever or slide L. The latter is at the end of a lever hinged at one end to the carriage and carrying the runner or bowl L^1. This is drawn along with the carriage, and the lever is consequently called the "trail" lever. As soon as K slips on to the bowl in L the "locking" lever and faller are said to be "locked," and are then in a position to begin winding.

This action is practically simultaneous with the termination of backing-off. This method of locking the faller is now general, having quite superseded the older method of locking at the top.

(306) In order to render the action of backing-off more perfect, and to ensure that the slack of the yarn, as it is unwound, shall be taken up by the faller, Messrs. Platt Brothers and Company have adopted the mechanism also shown in Fig. 160. The reversal of the direction of rotation of the spindles takes place a little in advance of the downward movement of the faller, and it is therefore found that a short length of yarn is unwound before the faller presses upon it. The actual extent of the unwinding is relatively greatest when the cop is almost built. It therefore becomes necessary to expedite the action of the backing-off chain

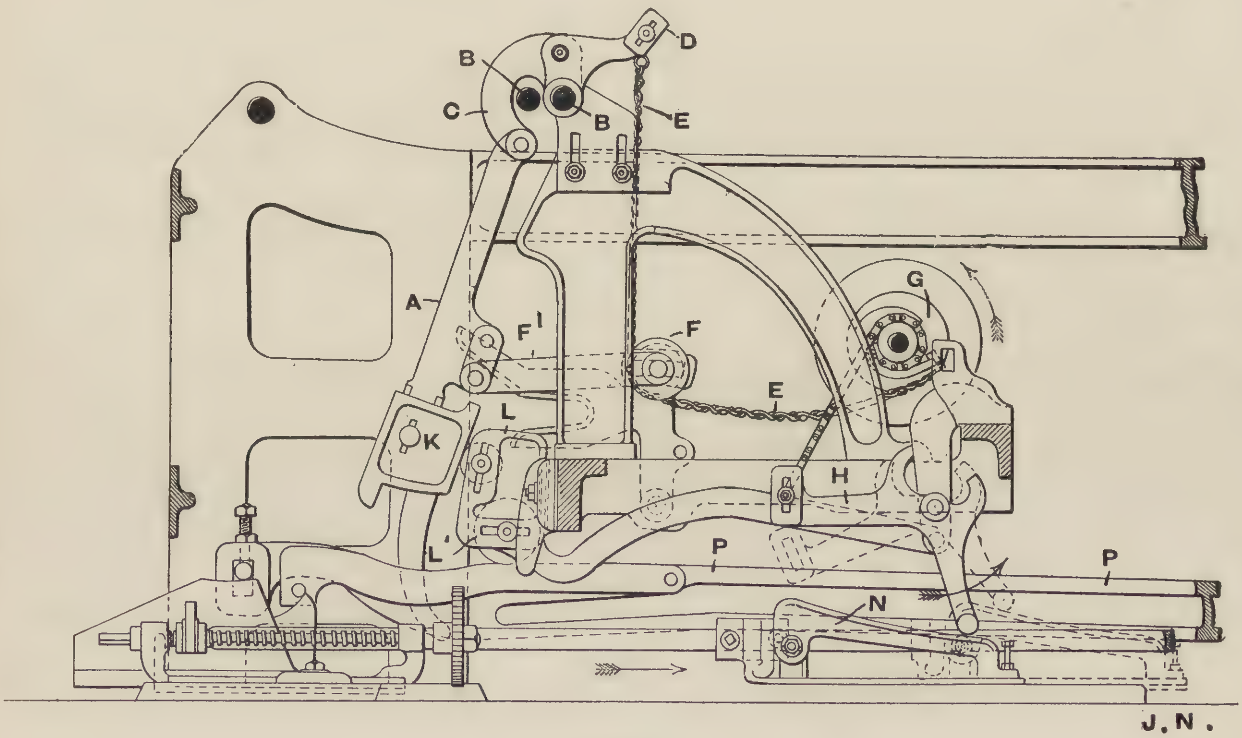


Fig. 160.

as the cops are built, so that the faller is drawn into contact with the yarn at the earliest moment. A little reflection will show that at the period when the cops are beginning to be built the faller wire has a much longer distance to travel than when they are almost finished. As will be afterwards shown, the period at which the faller is locked is gradually made earlier as building proceeds, so that a much shorter traverse of the faller prior to locking takes place correspondingly. Thus, for instance, if it has to be depressed one inch before it touches the yarn at the commencement of a set of cops, the relative proportion of that distance to the whole traverse prior to locking is less than when the traverse is so much diminished at the end of a set. Thus it follows that a degree of lagging permissible at one stage is absolutely detrimental at the other. From this it may be

deduced that an earlier and accelerated motion of the faller is necessary in order to take up the slack yarn during backing off.

(307) It is hardly practicable to fit a motion of absolute accuracy to effect this purpose, but an approximation to it can be obtained. It is, therefore, arranged that at the beginning of a set the backing-off chain shall be slack, and during building shall be gradually tightened until at the end of it is nearly in a state of tension. The snail is proportioned so as to give a quick downward movement to the faller, and in combination with the

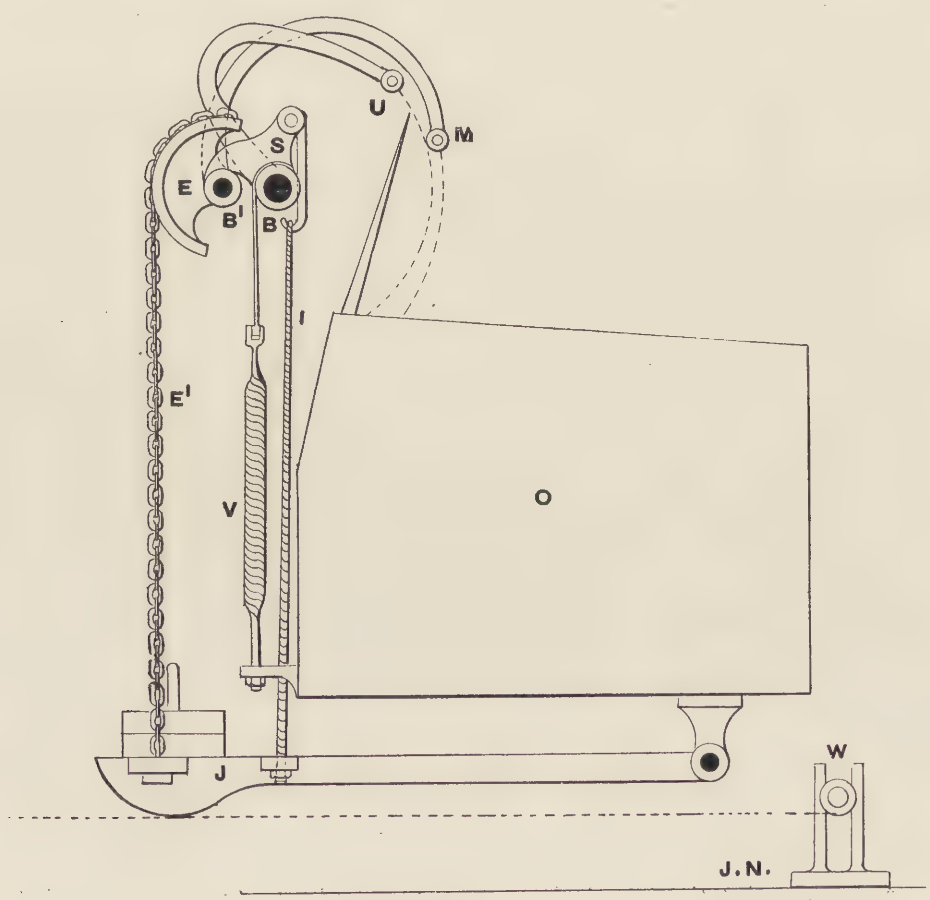


Fig. 159.

arrangement about to be described gives very good results. Referring again to Fig. 160, attached to the snail G is a second chain, the other end of which is fastened to a lever H, hinged on the bracket shown. The other end of H rests on an inclined plate N, which slides on a bedplate fastened to the floor. The plate N is fastened to the copping plate connecting rod—afterwards referred to—which passes through a horn fastened on N. As the copping plate is moved in, H is also caused to assume the position indicated by the dotted lines, N having also moved in. The effect is that a pull is put upon the snail which gradually rotates it, and causes it to wind on

the slack of the chain E, so that, when backing-off occurs, the faller is drawn downwards at an earlier moment. The restoration of N to its original position accompanies that of the copping plate, and is made at the beginning of a new set of cops.

(308) The various movements in connection with backing-off having thus been described, it is necessary to show how the traverse of the faller is obtained during the inward traverse of the carriage. This is shown in Fig. 161, page 205, which is a separate view of the copping or building mechanism. The faller "locking" lever A is, as has been described, raised until the shoulder R slips on to the slide L, in which position it remains until it is released at the termination of the inward run. On the underside of L a small bowl or runner L^1 is carried, which rests upon the upper surface of a longitudinal, or "copping" rail P, made of a strong section. If the latter was placed in such a position that its upper surface was horizontal, it is plain that the slide L would receive no vertical motion during the period that the runner L^1 was traversing it. In consequence the sickle U would remain in one position during the same time. But if the rail P is raised at one end so that its upper edge is inclined, the slide L will, during the run in of the carriage, receive a vertical traverse corresponding to the difference in the altitude of the two ends of the copping rail. That is to say, if one end of the rail was six inches from the floor line, while the other end was seven, L would ascend or descend to the extent of one inch while it was travelling from one end to the other of the rail P. The question as to whether it would ascend or descend depends entirely upon which end of the rail was highest. From this it may be inferred that by varying the angularity or profile of the copping rail any desired traverse, either regular or intermittent, could be given to the slide L. Now it was shown that the winding faller sickles are keyed on the shaft B, which is oscillated by the backing-off finger D fastened upon it. The latter being jointed to the "locking" lever A, it follows, that, as the latter is raised, the winding faller moves in an arc, which corresponds in length and direction to the length and inclination of the copping rail.

(309) It is necessary when the carriage arrives at the end of its stretch to lock it in that position during the time that backing-off is taking place, and the motions of releasing the counter faller and locking the winding faller are in operation. A reference to Fig. 162 is necessary to understand this part of the mechanism. That illustration is a diagrammatic representation of the mechanism relating to locking the carriage, and the engagement and disengagement of the taking-in gear. The parts are not in their working position, but are projected so that their operation may be better understood. The actual relative position of the various motions is shown by the diagrammatic sketch in the right hand top corner of Fig. 162. Upon the carriage O a bracket O^1 is fixed, which carries at its outer end a pin or catch, with which the hook at the end of the horizontal arm of the L lever S can engage. The hook readily falls over the pin in O^1, as the carriage is pushed up to it near the end of its traverse. The lever S is coupled in the manner shown to the horizontal rod R, which, at its other end, is jointed to a bell crank lever U^1. The rod R, on account of its function, is termed the "holding-out catch rod." The lever U^1 is in turn connected with the rod U, jointed at its upper end to the lever W, which is coupled to the horizontal arm of the lever Z^1 by the connecting rod M. A connection is thus established between the cam Z on the cam shaft and the "holding-out" catch lever S. During the run out of

the carriage the friction clutch I^1 K is disengaged by means of the lever W. The rod R is also locked by the small vertical slide S^1, which engages with the catch notch formed in it. The movement of the backing-off rod X, which is hinged to the lever L, causes the projecting arm in the lever Y to be pushed under the end of the lever W, thus sustaining the latter and preventing the engagement of the upper half I^1 of the taking-in friction with the lower half K. This action occurs just before the termination of the outward run, being a little in advance of backing-off, but simultaneous with the compression of the backing-off spring on X. Whatever movement of W may take place after the arm on Y is thus projected into the path of the end of the lever W, the friction cannot fall into gear until the support of the arm is withdrawn. The whole of these parts are thus locked together, and fall into gear simultaneously. It will be noticed that the connection between the lever S and the rod R is such that the latter can make a certain movement forward before the lever falls. Further, the carriage can be arrested during its outward run by the pedal lever fixed to the floor.

(310) The action of the mechanism is as follows: When the carriage arrives at its outermost point the connecting rod R is unlocked, and is free to move. In this way the catch lever S can be easily raised by the bracket on the carriage O, over which it falls, and securely holds it, the slot in the rod R permitting this movement. In this position it remains during the whole period of backing-off, when in a way which is afterwards described, it is released simultaneously with the taking-in friction with which, as shown, it is connected. The locking of the carriage is the last operation requiring explanation before proceeding to deal with the movements, which, together, make up the fourth stage or period. This is the one in which the nicest problems require solution, and in which the mechanism used is the most ingenious.

(311) The first step in commencing to wind is, of course, to release the carriage and draw it in. Before proceeding to show how this is effected, it will be as well to recapitulate and describe the position of the various parts. The strap is entirely upon the loose pulley; the backing-off friction clutch is in gear; the spindles are revolving in the opposite direction to that normal to them; the winding faller is drawn down and locked in a position a little below the nose of the cop; the counter faller is held just out of contact with the threads, but free to rise as soon as an inward movement of the carriage occurs; the roller and back shaft clutches are disengaged; and the upper half of the taking-in friction is out of gear with the lower, but revolving with the vertical shaft on which it slides.

(312) When the chain E (Fig. 160) has sufficiently raised the faller locking lever A to permit it to lock, the swinging lever V is suddenly drawn back. An examination of the drawings, either Fig. 160 or Fig. 161, will show that so long as the face of the locking lever presses against the face of the slide no lateral movement of the former is possible. Further, the connection established between the locking lever A and the lever V, by means of the lever F^1, ensures that as soon as the inward movement of the lever takes place when locking occurs, the lever V must necessarily oscillate on its pivot. This movement of the lever V causes its lower jaw to exercise a pressure upon the lever L in the contrary direction to that previously noted, and so draws the stop X^1 in contact with the bottom of the backing-off lever D. This action is aided by the spring on the backing-off rod, which is free to extend, and its whole force can be exerted on the lever D. In this way D is drawn back, and the backing-off clutch is disengaged.

(313) The same movement draws away the supporting piece on the vertical lever Y, and allows the upper half of the taking-in friction to fall into gear with the lower half, this action being aided by the spring Q. The slot in the end of the connecting rod M permits the upward movement of the left hand end of the lever W to be made rapidly and freely. In this way the engagement of the friction clutch is a very quick one. This upward movement of the lever W is communicated, in a manner described, to the holding out catch, which is also raised nearly simultaneously, and the carriage released.

(314) It is, of course, highly essential that all the three releasing motions shall be accurately "timed," so as not to take place either before or after the proper moment. Accordingly, ample means of

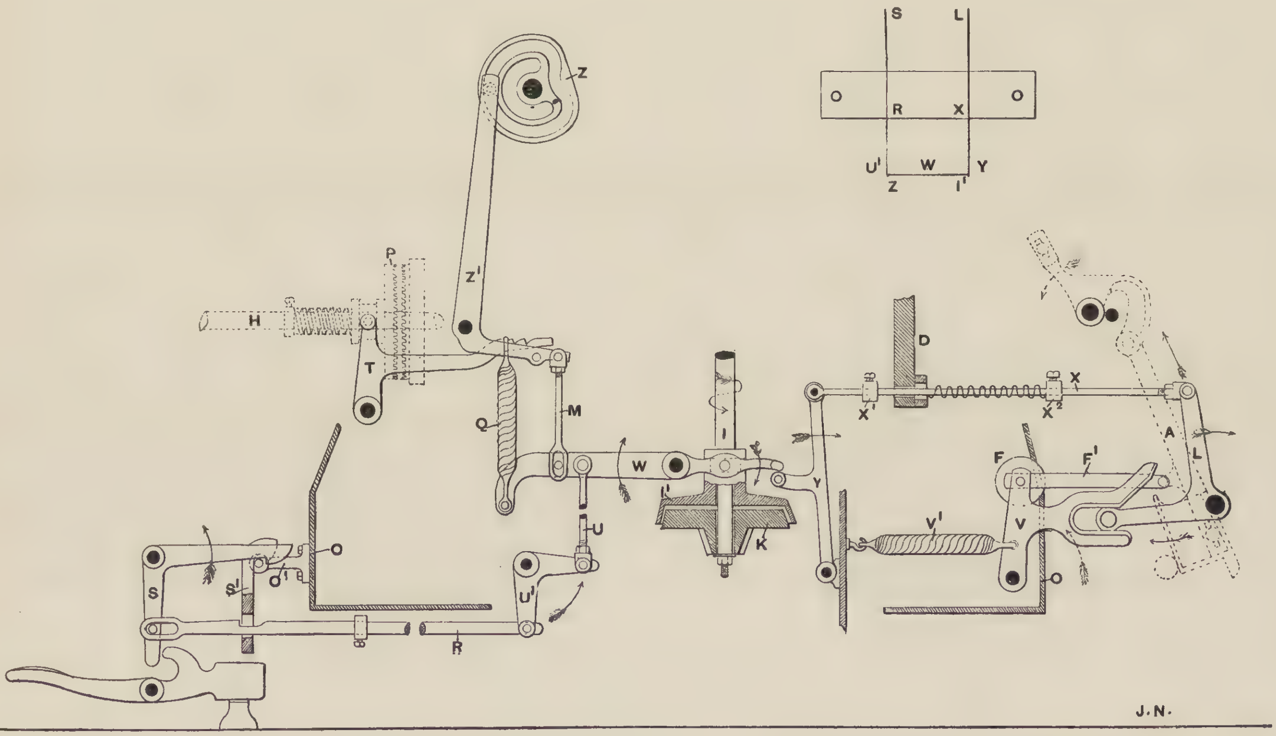


Fig. 162.

adjustment are provided, both on the rod X by the regulation of the stops X^1 and X^2; on the connecting rod M coupling the levers Z and T; and also on the holding-out rod. In this way it is possible to secure that simultaneous movement of the three parts, which is so essential for effective working. It is obvious that the backing-off friction and holding-out catch must be released before the taking-in friction gears, but the interval between these is so slight that they occur practically simultaneously.

(315) The taking-in friction being in gear, the rotation of the loose pulley is, by the train of wheels shown, communicated to the "scroll" shaft, on which the taking-in scrolls are fixed. These have bands

attached to and wrapped round them when the carriage is at the roller beam. As the carriage runs out, the bands, which are fastened to it, are drawn off the scrolls, the scroll shaft being then free to revolve. The engagement of the taking-in friction reverses this process and winds on the bands, thus drawing up the carriage. It will be observed that the scrolls vary in diameter, being about 9 inches in the largest part, and about 3 inches in the smallest. The reason of this construction is to give a varying traverse to the carriage, so as to start it easily, and bring it up to the back stops gently. The scrolls are designed so that, so long as they are revolving, they exercise a pull upon the carriage which is steady and constant. In this way, over-running is avoided, but to prevent any possibility of it a scroll L^1, shown in a detached position in Fig. 153, is fixed on L at an angle of 180 degrees to the others, the point of attachment of its rope being diametrically opposite that on the other scrolls. Thus when the bands on the drawing out scrolls are unwound, that on the "check scroll" is wound and vice versa. The purpose of this scroll is, as its name indicates, to check any tendency to over-running, which it effectually does. In all mules above a certain length, it is desirable to provide some means whereby the carriage shall be drawn in evenly throughout its length, and shall not be in danger of twisting or warping. The scroll shaft, it will be noticed, only extends across the headstock, so that the bands can only exercise any pull on the square, and if no other points of attachment were made, the carriage would at its extremities lag behind the centre. A considerable amount of friction would be thus caused, and the spindles at the end of the carriage would not take up the full length of yarn. It was shown that the back shaft is, during winding, disengaged, so that it is only necessary to establish a connection between it and the scroll shaft, to enable the carriage to be drawn in at several points throughout its length, instead of at one only. Accordingly, the scroll shaft is extended, and an extra scroll shown in Fig. 154 at the right hand side is fitted, from which a band is taken to a drum upon the back shaft. Thus the back shaft is converted into a taking-in shaft, and during that operation revolves of necessity at a variable speed given to it by the scrolls. In this way the carriage is kept parallel to the roller beam throughout its course, and comes up to the back stops along its entire length at one time.

(316) The arrangements for taking-in having thus been described, it now becomes necessary to describe the operation of winding. Before doing so, it will be better to deal with the problem to be solved, and it will aid in understanding it if the construction and method of building the cop be described. For this purpose a reference to the diagrams given in Figs. 163 and 164, page 207, is necessary. The cop is built, as before explained, upon the blade or taper part of the spindle, and, when finished, is of the shape shown in Fig. 163, viz., a cylinder with conical ends. The central part of the cop, E G K F, is cylindrical, and at the top and bottom of this part are two cones. The lower cone, A E B C F D, forms what is known as the "cop bottom," and the upper one, G H I K, the "nose," although the latter term is more often and strictly applied to the extreme apex at the points H I. As previously stated, the yarn may be wound either upon the bare spindle, upon a short paper tube, as indicated by the thick line inside the cop bottom, or upon a similar tube the whole length of the cop. The use of paper tubes of this character is preferable, especially in cases where the cop is likely to be much handled, as it prevents it from being crushed in, and enables

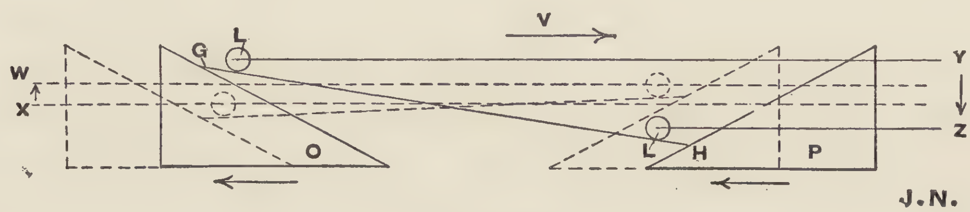
the introduction of a skewer for subsequent winding without there being any danger of the cop being pierced or "stabbed," this being a fruitful source of waste.

(317) In commencing to wind, the yarn is wrapped on the lower part of the spindle in close coils or spirals for a length of a little more than an inch. The whole of one stretch is wrapped upon this space, and when the next stretch requires winding, it is laid upon the previous layer, and so on until the double cone A E B C F D is produced. The length of the traverse of the winding faller wire, or the length of each layer vertically, is called the "chase" of the cop or faller. From this point the yarn is wound in successive layers, beginning always at a higher point, until the final traverse is obtained by which the winding is conducted upon the surface or nose represented by the letters G H I K. It was stated in paragraph 311 that the winding faller wire, when the winding faller is locked, is in a position a little below the point H I. As soon as the carriage begins to run in, the vertical movement of the winding faller locking lever begins, and is so arranged that the first movement of the wire is a rapid downward one. The effect is that the yarn is laid on the nose of the cop in coarsely-pitched descending spirals, as shown in Fig. 164, these extending downwards until the winding faller wire reaches a point opposite the base of the upper cone, in this case shown in Fig. 163 at K. From this point a slower ascent of the winding faller wire is made, so that the yarn is laid in the more finely pitched spirals shown, until the nose of the cop is reached. By this time the carriage has arrived at the roller beam, and the whole of the 63 inches of yarn has been wound.

(318) When the first layer of yarn is wound, and the winding faller is assuming its position to wrap on the second, the initial point of its traverse is a little raised. In this way the yarn is gradually wound in layers, which are represented by the angular lines springing from the lines A E and D F towards the spindles During this period the enlargement of the diameter of the cop bottom is proceeding until at the points E F the full diameter of the cop is reached. As soon as this occurs the initial point of each layer is gradually raised, and the length of the traverse is slowly diminished as the completion of building is approached, until at the termination of a cop the angle of the layers is shown by the lines G H and I K. There are thus two adjustments shown to be necessary—First, the starting point of each traverse of the winding faller requires altering; and second, its extent also needs regulation.

(319) These two objects are attained by the regulation of the copping rail P, as shown in Fig. 161 The ends of this rail rest upon inclined "copping" plates Y X, which are fastened together by the rod W, and which receive, as will afterwards be described, an inward movement during the building of the cop. It was shown that the locking of the faller lever and its vertical movement leads to a corresponding movement of the faller. If, for instance, the faller locking lever fell an inch, the winding faller sector would be oscillated and the faller wire drawn upwards. The rate of the ascent of the latter is absolutely relative to the period of the descent of the locking lever. Referring now to Fig. 165, which is a small diagrammatic sketch of the copping rail and its supports, suppose the line G H to represent the top of former, O P the latter, and L the bowl at the foot of the locking lever, if L, starting from the left hand position, be supposed to travel in the direction of the arrow V, it will be seen that it will fall to the extent indicated by the space Y Z. If, on the other hand, the slides O P

are moved into the position shown by the dotted lines, the rail G H will also fall into that indicated in a similar manner. The result is that if L now makes the same traverse as before it will rise a little as indicated by the space W X. The effect on the winding faller would be that in the first case it would be raised, and in the second it would be depressed to an extent corresponding to the depression of the locking lever. The extent to which this elevation or depression is made depends upon the vertical traverse of the locking lever, and the ratio of the distance of the point of junction of the sector C with the faller shaft and that of the faller wire from the



, 165.

same rod. If, for instance, this proportion was 1 : 2, an elevation of the locking lever half an inch would result in a depression of the faller an inch. It is therefore necessary, during the inward run of the carriage, to provide for the inclination of the carriage to such an extent as to secure the requisite traverse of the faller wire. As the amount of such traverse varies during the building of the cop, it follows that the inclination of the copping rail must be varied correspondingly.

(320) Referring again to Fig. 161, the ends of the copping rails have pins fixed in them, on which are anti-friction bowls, which run upon the edges of the copping plates. The latter are duplicated, so as to sustain the rail at each side, and thus maintain its vertical position. At one side of one of the plates Y is an ear S^1, which is threaded to correspond with a square threaded screw S passing through a fixed bracket fastened to the floor. In this way the screw S is free to revolve, but cannot make any longitudinal movement. On the end of the screw S a ratchet wheel is fixed with which a pawl S^2 engages, which is oscillated so as to move the wheel one tooth at convenient times. The speed of the revolution of the screw varies according to the counts being spun, the elevation of the point of locking being more quickly effected when coarse yarns are being made than when the finer varieties are produced. Whatever may be the velocity at which this elevation is accelerated, the profile of the copping plates is such that the inner end of the copping rail P is lowered at a more rapid rate during the formation of the cop bottom than at a subsequent stage. The reason of this will be easily comprehended, if the description of the mode of building the latter be borne in mind. It was then shown that the traverse of the winding faller rapidly increased in extent until the full length of the cop bottom was built. It, therefore, follows that the descent of the locking lever must be largely increased at this period at a quick rate, in order to produce the result indicated. When the outer end of the copping rail begins to descend at a rate which more nearly corresponds to that of the inner end, it gradually approaches to the horizontal, and the vertical motion of the slide, locking lever, and faller is proportionately limited.

(321) The regulation of the winding faller as just described was the one which was usual until recent years. It has been found necessary, however, to obtain a more accurate regulation, so as to ensure that the faller wire shall be in its correct position when locking occurs, especially during the period between the beginning of a cop and the attainment of its full diameter. It is now customary to attach to the front end of the copping rail a loose plate Q, which is hinged at one end to the rail, and which carries at its outer extremity a pin and bowl resting upon a third inclined plate Z. By varying the profile of the plate Z, the regulation of the faller during the early part of its traverse can be accurately made and the proper position of the wire ensured. As a glance at the illustration will show, the upper edge of the copping rail is not straight, but is shaped so as to give a variable speed to the slide L in its vertical movement. The proper shaping of the copping rail gave rise to some difficulty, and it will be seen that the loose copping rail Q is shaped so as to produce the proper effect, while being much more easily adjusted.

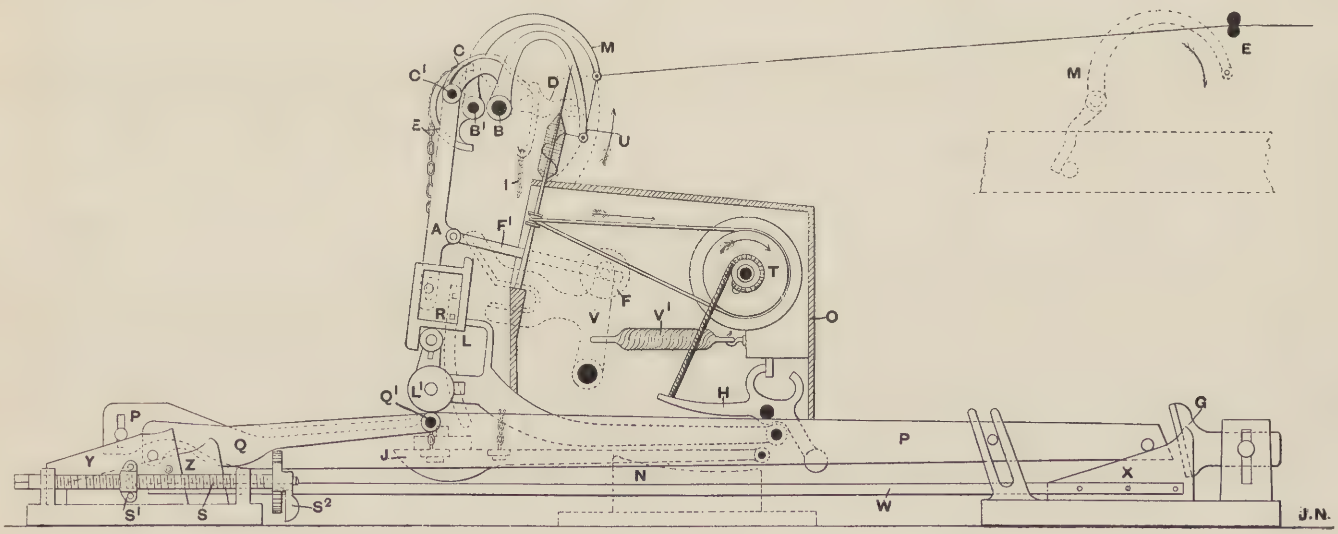


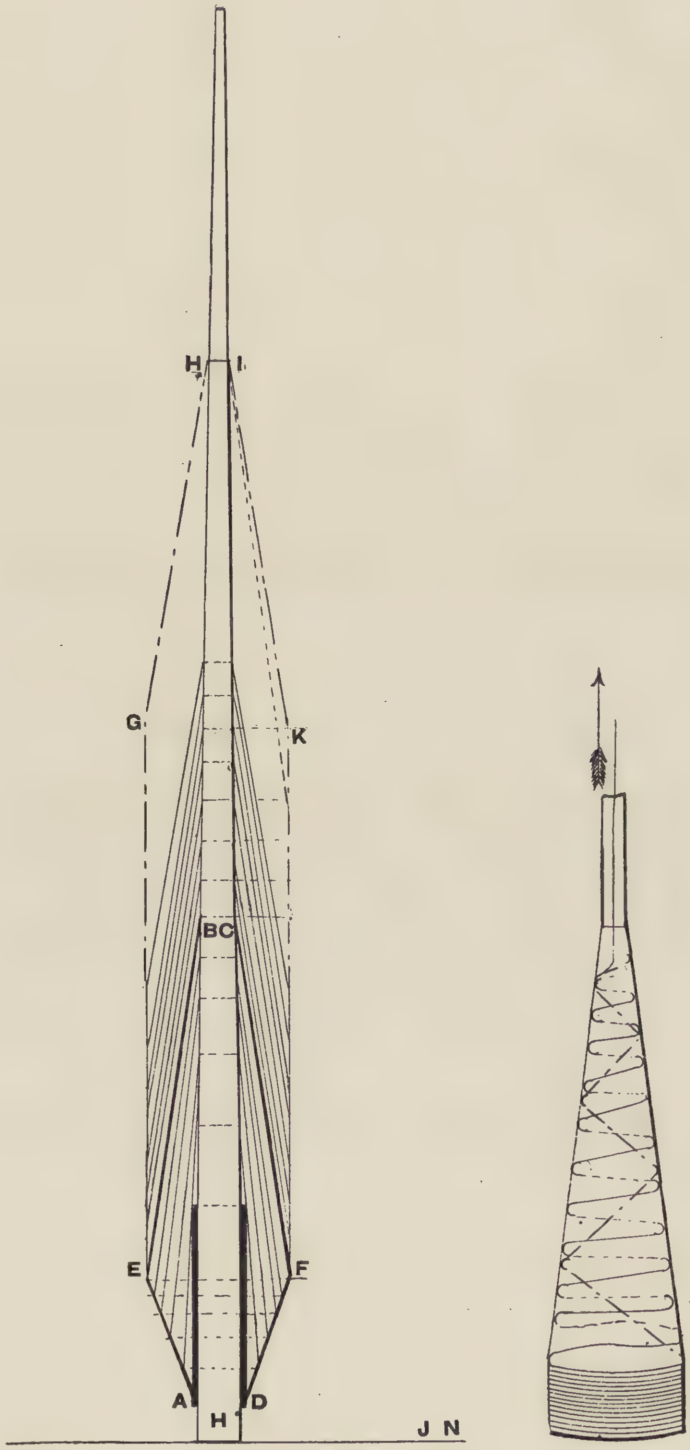
Fig. 161.

(322) The actual operation of this mechanism is as follows: When the carriage is at its outermost point, and the winding faller is locked, the wire is, as previously mentioned, a little below the nose of the cop. As the inward run proceeds, the bowl first runs up the loose incline, thus raising the locking lever and depressing the winding faller wire. The distance, from the extreme outward point reached by the bowl L^1 and that where the loose rail Q is hinged and the downward inclination of the copping rail begins, is so short that the initial depression of the winding faller is very rapid. This produces the coarsely pitched coils referred to in paragraph 317, and illustrated in Fig. 164. By the time the bowl L^1 is at its highest point the winding faller wire is opposite the base of the upper cone. The subsequent downward inclination of the copping rail is much less acute, and the consequent descent of the faller locking lever less rapid. As a result the upward traverse of

the winding faller wire is made more slowly, and the yarn is wound in more finely pitched spirals. It only remains to be said, in connection with this part of the subject, that owing to the shape of the copping plates their inward movement is accompanied by a gradual fall of the copping rail, and, consequently, the locking point of the faller lever is relatively elevated. In other words, the traverse of the locking lever prior to locking is gradually lessened as the trail lever slide L is lowered, and this is equivalent to an elevation of the winding faller lever and its locking point or shoulder K. This causes the depression of the winding faller wire prior to locking to be gradually diminished, so that there is an elevation of its initial point.

(323) The method of obtaining the traverse of the winding faller having been described, the equally important points relating to the mode of rotating the spindle during winding require to be dealt with. A little thought will show that so long as the surface upon which the yarn is wound remains small the spindles must revolve at a more rapid rate than when the surface is enlarged. As the extreme diameter of the cop bottom is enlarged the conditions of successful winding are continually changing. At the commencement of the cop the yarn is wound upon what is practically a parallel surface with a diameter of $\frac{5}{16}$ inch and a circumference of ·98 inch. This implies that to wind the 63 inches of yarn 64·3 revolutions are required, these being made during the run up of the carriage. But as the diameter of the cop is enlarged the circumference of the conical surface becomes a variable one, and owing to its enlargement the number of revolutions required to wind the same length of yarn is fewer. This is quite clear and needs no demonstration. Thus when the cop bottom is formed the extreme range of variation is reached, and it follows that in the interval between the commencement of winding and the formation of the cop bottom each stretch must be accompanied by a diminution of the velocity of the spindle proportionate to the increase of diameter. In addition to this it is necessary to take into consideration the varying diameter of the conical surface on which winding takes place, which necessitates a greater terminal than initial velocity of the spindle.

(324) A further point requires elucidation. If the spindle blade were parallel, the number of revolutions necessary to wind the 63 inches of yarn properly, when the cop bottom is formed, being fixed, no further alteration would be necessary. But these conditions do not exist, and the nose of the cop is wound upon a continually diminishing diameter. It is of the utmost importance that the yarn is wound tightly at the nose during the whole of the building of the cop. The rate of the vertical traverse being practically uniform, unless an acceleration of the spindle velocity occurred, there would be slack winding during the latter part of the building of the cop. This would produce a sponginess of the nose, which, when the yarn was drawn off in the subsequent process of winding, as shown by the arrow in Fig. 164, would result in several rings or coils being pulled out in an entangled condition, thus producing waste. Technically the cop would be said to be "halched." Illustrating this part of the subject by figures, if the diameter of the spindle at the point B, Fig. 163, be assumed to be $\frac{1}{4}$ inch, its circumference would be ·7854 inch; while if the diameter at H be assumed to be $\frac{1}{8}$ inch, the circumference would be only ·3927 inch. To wind, say, 10 inches of yarn in each case, would require about 12 and 25 revolutions of the spindle respectively. It is therefore clear that, if the same length is to be wound with equal tension upon the nose of the cop



Figs. 163 and 164.

throughout the whole process of building, there must be a gradual acceleration of the terminal velocity of the spindle. Although this is only slight at first it is required at an earlier point as the cop is formed, and becomes of increasing importance.

(325) It will be shown, a little later, that the rotation of the spindles during winding is obtained by the pull of the carriage on a chain, which has its other end attached to an oscillating arm, being fastened to a drum on the carriage. To get a clear idea of the action of this part of the mechanism the two diagrams shown in Figs. 166 and 167 are given, a study of which will be profitable. In Fig. 166 the circles B C D represent three positions of the barrel or drum after it has moved in a horizontal plane in the direction of the arrow. To the drum a chain is supposed to be attached, which is held at the point A. It is, of course, understood that the barrel is mounted upon a shaft or axis so that it can freely revolve. If it be now assumed that the barrel is in the left hand of the three positions B, the chain will be wrapped completely round it. As it is moved horizontally in the direction of the arrow it is revolved, as indicated

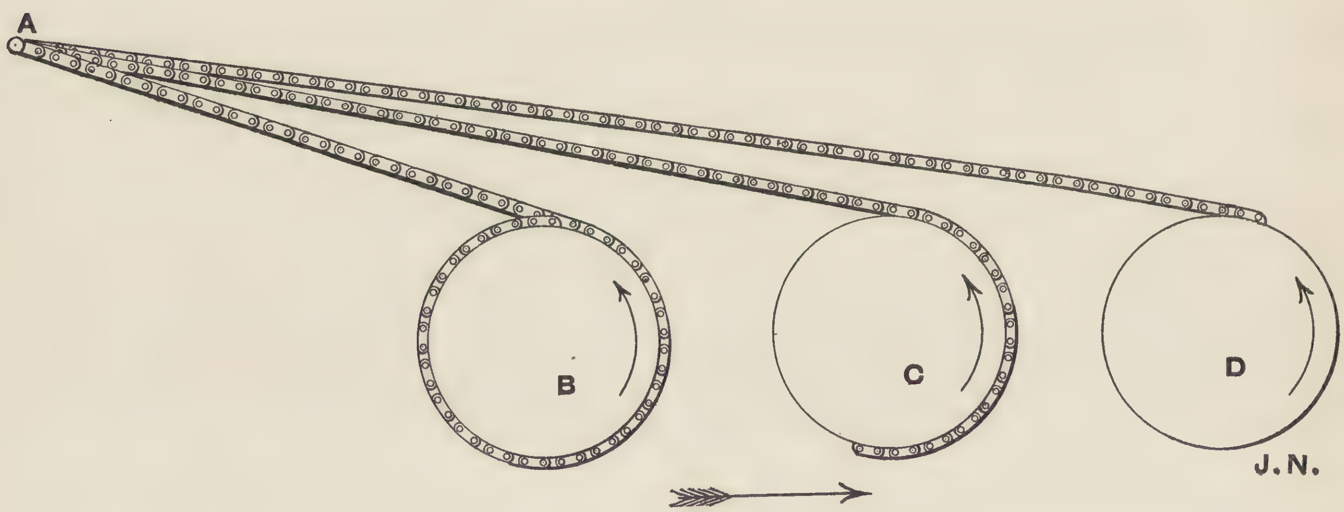


Fig. 166.

by the curved arrows, and, by the time it has reached its middle position C, has been rotated sufficiently to unwind about half a turn of the chain. A further horizontal motion to the right hand position D will complete the unwinding, and, by this time, the drum will have made one complete revolution. It will be at once seen that the rate at which the drum will be revolved will depend upon two factors—its diameter, and the speed of its horizontal traverse. If the point A at which the chain is held is stationary, and the horizontal movement uniform, then the rotation of the barrel will be constant. But if the barrel be traversed at a variable rate then its rotation will also be variable. In actual practice this uniformity does not exist, for, as was shown in paragraph 315, the taking-in scrolls vary considerably in diameter. Assuming this variation to be 1 : 3 : 1, it would follow that the rotation of the barrel would increase and diminish in the

same ratio. In practice this is what happens, and the speed of the revolution of the barrel is quicker about the middle of the taking-in than at any other time.

(326) The assumption that the point A is stationary was only made to illustrate the point at issue, and is not founded upon the actual facts of the case. If now it be assumed that not only the barrel but the point at which the chain is held makes a forward movement, a new set of conditions arises. In this case the unwinding of the chain during a given time will be diminished by the amount of the advance of the point A in the same period. Assuming the latter to be made at a regular rate it would be easy to calculate the extent of the unwinding. If the effect of the horizontal movement of the barrel from B to C be to unwind half of one coil of chain—say a length of 7 inches—and that in the same space of time the point A moved 3 inches, the amount unwound would be reduced to 4 inches. But this is not the actual condition of things in practice. The point moves at a variable velocity, its forward motion gradually diminishing, so that the acceleration of the rotary velocity of the barrel is greater at the end of its horizontal traverse than at the beginning. In other words, its terminal velocity is highest.

(327) The point of the attachment of the chain at A is made in an oscillating arm which, during the inward run of the carriage, receives a forward movement at a speed which is controlled by the velocity of the back shaft. As the latter is, in turn, commanded by the scroll shaft during this period—see paragraph 315—it follows that the variation in the forward movement of the arm is coincident with that of the carriage. Thus the advance of the point A will always be in strict correspondence with the velocity of the carriage traverse.

(328) Referring now to Fig. 167, and, assuming A B to be the arm to which the chain is fastened, and O J and H C to represent the arcs through which the point of attachment of the chain travels at different times, it will be seen that the periods of movement are well marked. In each case the arcs are of the same number of degrees, although the chord of one is shorter than that of the other. Dealing first with the inner arc, which represents the position of the point of attachment when nearer the centre, the whole period of movement is divided into equal parts. These are represented by the letters J K L M N O. Now, if vertical lines are drawn from these, until they terminate in a straight line drawn parallel to a horizontal line through the point B, a clear idea can be formed of the effect of the oscillation of the vertical arm A B. The lines terminate at J^1 K^1 L^1 M^1 N^1 O^1. It can be easily seen that the horizontal movement of the point of attachment of the chain gradually becomes less as the arm is oscillated from its most backward position B C to its most forward one B H, this diminution occurring most after the point L is reached. In the movement from J to K and K to L the horizontal traverse is about equal. It shows a decrease from L to M, a greater one from M to N, and a still greater one from N to O. The same thing happens if the chain be supposed to be attached at the point D. In this case also the decrease in the horizontal forward traverse is variable, but occurs in the same way. The periods here are marked by the letters C to H, and the extent of the forward motion by those C^1 to H^1. It will be noticed that the amount of the traverse is greater than that previously noted, the total space covered being respectively J^1 to O^1 and C^1 to H^1. That is to say, the point at which the chain is fastened moves forward in the same direction as

the barrel, but at a different speed. In other words, when the chain is held at K, the total forward movement is comparatively small, and if it were held at a point shown by the small inner circle, it would be still less. On the other hand, its attachment at B implies a greater total forward movement. It therefore happens that the retardation of the chain by the arm is less in the early part of the oscillation of A B—or, to put it differently, the delivery of the winding chain by the arm is greater when it is fixed at D than when it is fixed at K. Therefore the barrel is more slowly rotated during the same period in the former than in the latter case, but as it completes its lateral movement it is rapidly and considerably accelerated.

(329) The application of this principle is as follows, and it can now be stated that the end of the chain is attached to a nut which slides along the arm, being actuated by the rotation of a screw upon which it fits. Remembering that an acceleration of the terminal velocity and a regulation of the revolution of the spindle is required, the demonstration just given shows that these are obtained by the removal of the nut further from the centre of oscillation. The influence of the pull of the chain upon the barrel when the nut is in the position K is much slighter, and shows less variation than when it is at D. Every inch which the nut travels outwards has an influence upon this factor, and the conditions of winding are thus accurately regulated. When the winding of the cop begins, the nut is in its lowest position, and the rotation of the barrel is then practically equal. As the nut moves away from the centre the barrel gradually rotates more slowly at the beginning of its inward movement. By the time the most outward position is reached—which, in practice, coincides with the formation of the cop bottom—the variation in the velocity has reached its greatest amount. This, it can be easily seen, is what is wanted. Referring again to Fig. 163, one revolution of the spindle when the yarn is being wound on A D would practically take up the same length as would be taken up at the top of the paper tube. But when the faller is guiding the yarn on the conical surface from E to B, one revolution of the spindle would wind on a greater length at E than it would at B. Therefore, the initial velocity requires to be less than the terminal. But when the point E has become the initial position, the conditions of winding remain thereafter constant, except in so far as is affected by the taper of the blade, and there is no further need for an outward movement of the nut.

(330) The theory underlying the method of winding having thus been dealt with, the mechanism employed can be described. This is shown in Fig. 168, which is a diagram of the whole of the apparatus, and in Fig. 169, which is an enlarged view of a portion of it. The winding arm M is centered at its lower end, and has formed on it a toothed quadrant M^1. The "quadrant" M oscillates on a short shaft, securely carried by the headstock framing, and receives its forward movement by means of a pinion Z, which engages with its teeth. The extent of the quadrant movement is about a quarter circle. The pinion Z is mounted on the same centre as a grooved pulley, over which a cord from the back shaft H is passed. Thus the rotation of H in either direction produces a similar movement in the pinion Z; and the effect is, that, while the back shaft is drawing the carriage out, the pinion is revolving so as to raise the arm M or cause it to make a backward oscillation. When the back shaft acts as a taking-in shaft, as described in paragraph 315, the pinion Z is revolved so as to move the arm M forward. The velocity at which the forward stroke is

made is by this arrangement a variable one, and completely corresponds to that of the carriage traverse. Inside the winding arm a long slot is formed in which a screw P is placed, this being free to revolve. It may be made with a thread of equal pitch throughout, but, as shown, is provided with a thread of varying pitch, which gradually becomes finer towards the outward end of the arm. The reason of this is obvious. The effect of each layer of yarn upon the problem of winding is greater at the beginning of the formation of the cop bottom than when it is more nearly finished. That is, the enlargement of its diameter is relatively

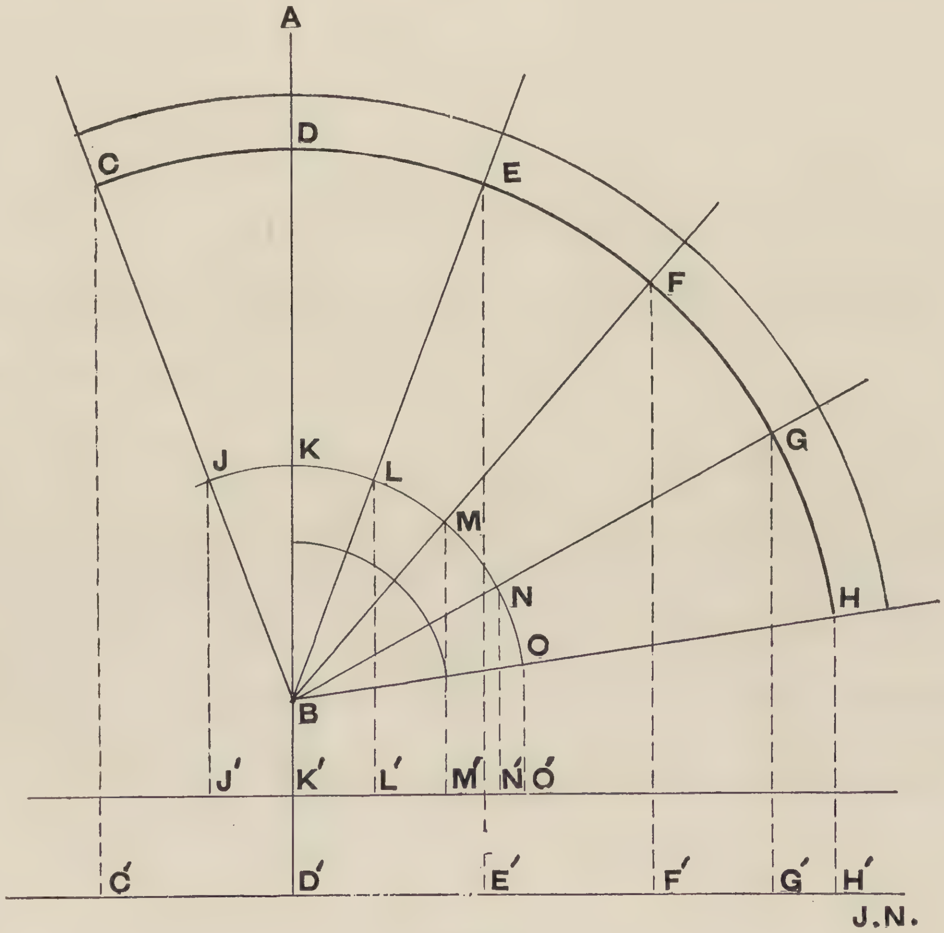


Fig. 167.

greater at the first stage than at any other. For instance, if the diameter is $\frac{3}{8}$ inch and it be increased $\frac{1}{16}$ inch, the ratio is $\frac{1}{6}$th; while if the diameter is $\frac{3}{4}$ inch, and the same increase takes place, the ratio is $\frac{1}{12}$th only. The variation required in the speed of winding as each layer is wrapped is therefore less in the latter than in the former case. This is the purpose of the helical screw, which gives a quicker advance to the nut in the earlier stages of winding than when the cop bottom is nearly formed.

(331) The screw has fixed upon it, at its lower extremity, a small bevel pinion, gearing with a similar one placed loosely on the short shaft forming the centre for the arm. During the oscillation of the arm the pinion moves with it, and it is clear that if both remained in this position only this alternate action would occur, and no rotation of the screw would be made. If, however, the pinion on the short shaft be rotated it communicates its motion to the screw P, and thus traverses the nut. This is what takes place, and the precise method of effecting it will be described in detail at a little later period. The nut engages with the screw and originally had an eye or hook formed in it, to which the end of the winding chain or

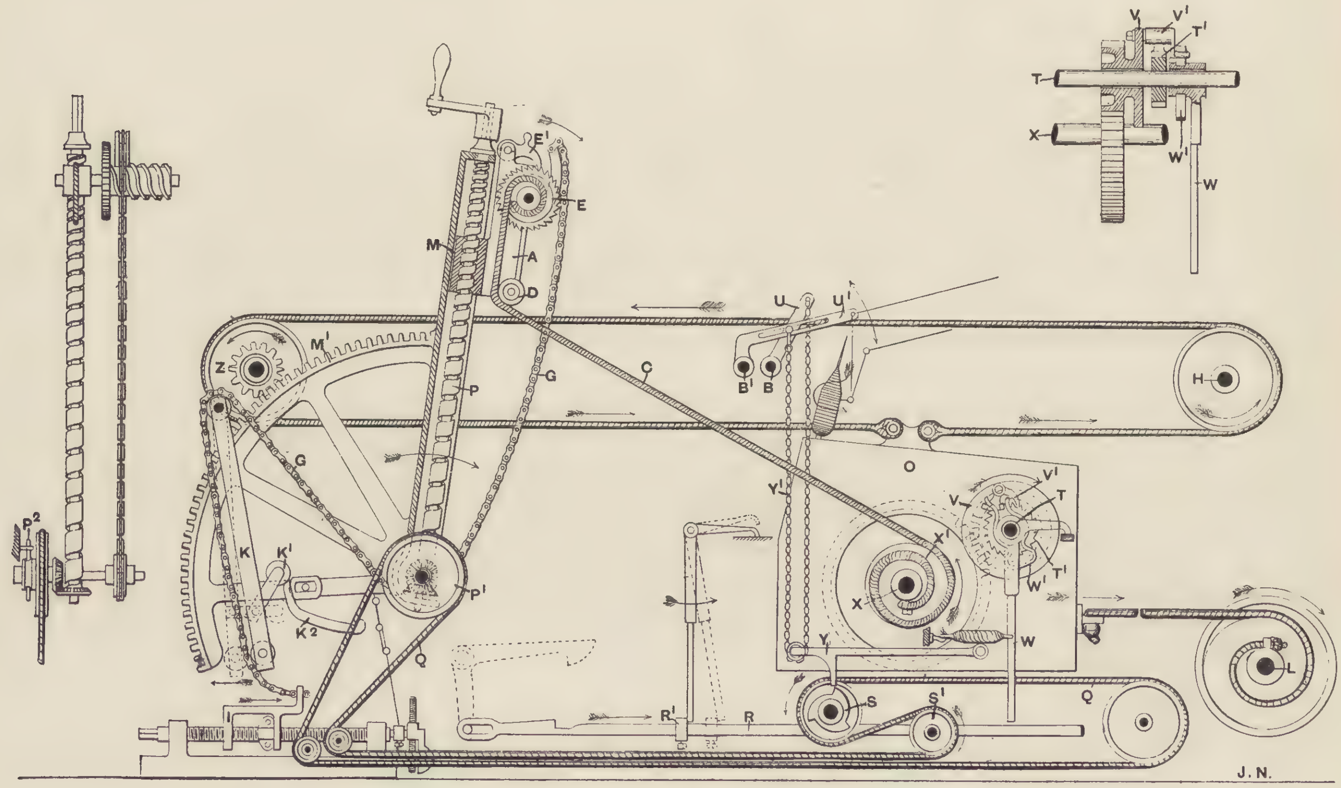


Fig. 168.

band C was fastened. The attachment is now made in a different manner, a frame A being fixed to the nut along with which it can slide. At the upper end of the frame a small drum is carried, round which the winding chain is wrapped, passing over a small bowl D at the lower end of the frame. The other end of the chain or band C is fastened to the drum or scroll X^1 which is mounted on a shaft X carried in suitable bearings in the square. On the same shaft a spur wheel is geared which engages with a pinion loose upon the tin roller shaft, which it revolves by special mechanism afterwards described in detail. The use of a scroll is intended to accelerate the revolutions of the spindles during the latter part of the fallen

traverse. This, like the winding arm, is a modified application of the fusee, and it will be easily understood that when the chain is being unwound from the larger diameter of the scroll, the number of revolutions given to the scroll will be less than when it is being taken off the smaller diameter.

(332) It has been previously shown that the diminishing diameter of the spindle causes it to be necessary that, as the cop is built higher upon it, a correspondingly higher rotary velocity shall be given to it, in addition to the increased terminal velocity produced in the manner described. The most usual method of doing this has been to provide at the end of the quadrant arm a bracket carrying a pin known as the "nosing peg." The object of this device is to shorten the chain by deflecting it from a straight line about the time when the carriage nears the end of its inward run. This is equivalent to a sudden shortening of the chain, and gives a sudden acceleration to the winding drum. In some cases an automatic arrangement is fitted by which the peg is brought into contact with the chain at an earlier point every stretch, so that the acceleration of the spindle takes place sooner, as the nose of the cop is formed higher up the spindle. It is not difficult to obtain a clear notion of the action of the nose peg if a short length of string be held at one end and attached to a sliding piece at the other. If then the string be pressed down by a rod at the same point, but a little further every time, it will be seen that the sliding piece is moved to a greater extent with each depression.

(333) The arrangement used in the Platt mule is shown in detail in Fig. 169. It consists of the sliding bracket A, carrying, as described, at its upper part, a small drum on which the winding chain C is fastened. On the spindle of the winding drum a ratchet wheel E is fixed, with which the detent pawls E^1 engage, thus ensuring that E is held in any position assumed by it. Also fastened on the spindle of the drum is the curved sector arm F, to which a chain G is secured. By means of the guide pulleys shown the chain G is conducted over the arm or lever K, and is attached to the bracket I. The lever K is hung from its upper end, and has a projecting short arm K^1 attached to it, which can move upwards in the direction of the arrow. The outer end of K^1 presses against a bracket K^2 attached to the quadrant, so shaped that the backward movement of the quadrant pushes the lever K back at its lower end. In the bracket I a finger I^1 engaging with the copping nut is fixed. The parts having been adjusted to their proper position the slide A is at the bottom end of the quadrant M, as shown, and the curved arm F is in such a position that it has wound upon it a certain length of the chain G. The latter is a little slack at first, but as the nut moves out this is rapidly taken up until the chain G is in tension. As soon as this happens, each of the forward oscillations of the arm M leads to the chain being drawn, and causes the lower end of the lever K to be swung forward. The return movement of the quadrant leads to the bracket K^2 pressing upon the arm K^1, so as to push back the end of the arm or lever K. In this way the chain G is pulled and the curved arm F is drawn a little forward, thus causing the drum and ratchet wheel E to revolve. As the winding chain is wound on the barrel, every rotary movement of the latter in a forward direction takes up a little more chain and shortens its length. The amount of this shortening is not great up to the time of the completion of the cop bottom and the arrival of the slide A at the end of its traverse along the arm. The position of

the parts at this period is shown in the detached view at the right hand top corner of Fig. 169. Up to this time only about the same length of chain is taken up which is needed by the increased distance of the slide A from the centre, and the greater forward traverse of the quadrant arm, which, in a sense, releases a certain length of winding chain. When this point is reached the finger I^1 begins to be pressed against by the nut S^1 of the shaper screw, and the bracket I commences to be drawn inward. To facilitate the correct action of this mechanism the finger I^1 is adjustable, and the exact moment of its contact with the nut S^1 is thus regulated. The forward movement of the shaper nut which follows gives a similar motion to the bracket I, and the chain G is thus drawn forward. In this way the drum and ratchet wheel E are rotated, and the winding chain gradually shortened. Thus more of it is unwound from the scrolls at each traverse of the carriage, and as it is drawn from the smaller diameter of the scroll towards the end of the run in, the velocity of the spindles is considerably accelerated. The position of the various parts when the carriage is at the back stops is shown in Figs. 170 and 171.

(334) These represent respectively the places occupied by the different portions of the mechanism immediately at the completion of the cop bottom, and at the finish of building a set of cops. The positions of the various parts connected with the slide A when winding is complete are shown also in Fig. 169, at the top end of the quadrant arm. Referring to Fig. 170, it will be noticed that the winding chain C is unwound from the large part of the scroll only, while Fig. 171 shows it almost entirely unwound from the smaller portion. As was shown, this implies a high terminal velocity of the winding scroll and spindles.

(335) It has been previously mentioned that the rotation of the quadrant screw is obtained by means of the engagement of two bevel wheels, one on the foot of the screw and the other upon the spindle, forming the centre of the quadrant. It was also stated that the last-named wheel was held so as to move round the centre with the quadrant. This is effected by means of a brake spring P^2 which clips the boss of the wheel and holds it. The resistance thus created causes the bevel wheel to move with the quadrant, and prevents it from rotating on its axis. The wheel is compounded with a grooved cord pulley P^1, over which an endless band Q passes. The band Q fits the groove in the pulley, and is afterwards guided by the various carrier pulleys shown. Two of these, S S^1, are borne by brackets fixed to the carriage, and S is formed with teeth so as to allow of the engagement of the vertical detent catch on the lever Y. If the whole of the pulleys over which the band Q passes are free to revolve, except that on the quadrant centre, the inward run of the carriage gives no motion to the cord or band. No effect is produced beyond the rotation of the carrier pulleys, and the forward stroke of the quadrant is made without any effect being produced upon the position of the nut.

(336) It was shown that the gradual accretion of yarn by the cop results in the necessity for a graduation of the velocity of the spindle in winding. This takes place during the whole period of building, and it follows that the traverse of the nut must be governed during the whole period. After a layer of yarn has been wound the nut remains in the position occupied by it during the preceding inward run, until the carriage has made another outward run, and is again commencing to run in. At the commencement of the run in

of the carriage the spindles revolve at the same speed as that at which they rotated in the preceding period of winding. If the yarn is a coarse one this is sure to be too fast, because of the increase in the diameter of the cop, owing to the yarn wound during the last inward run. The initial velocity of the spindles is, therefore, such that they take up the yarn too rapidly, and put an extra amount of tension upon it.

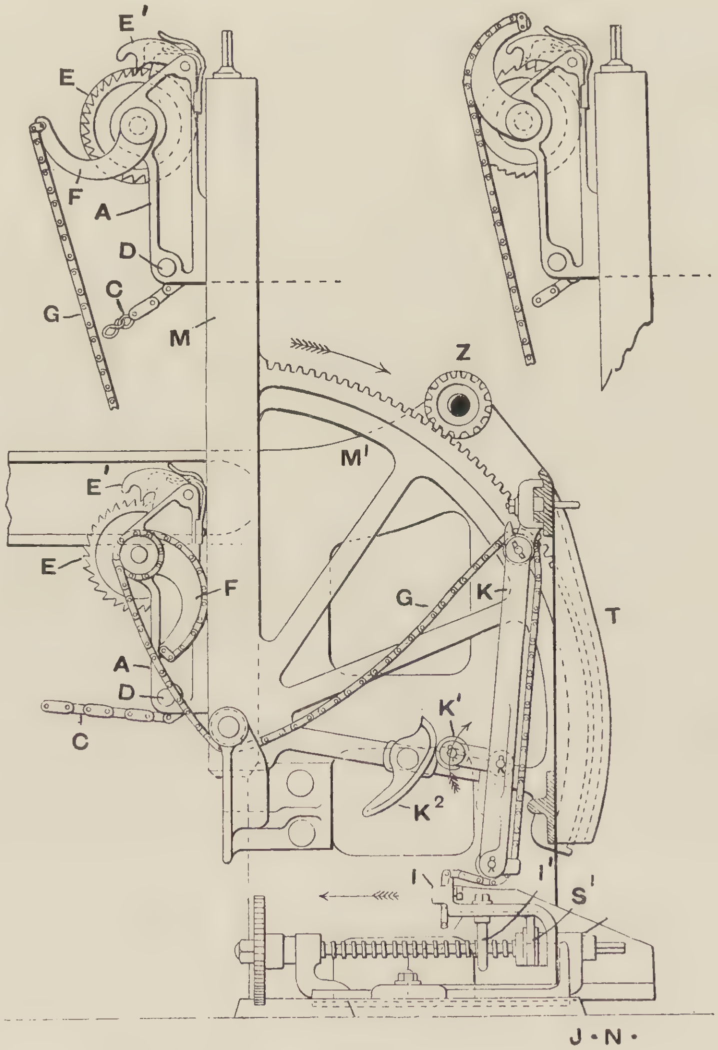


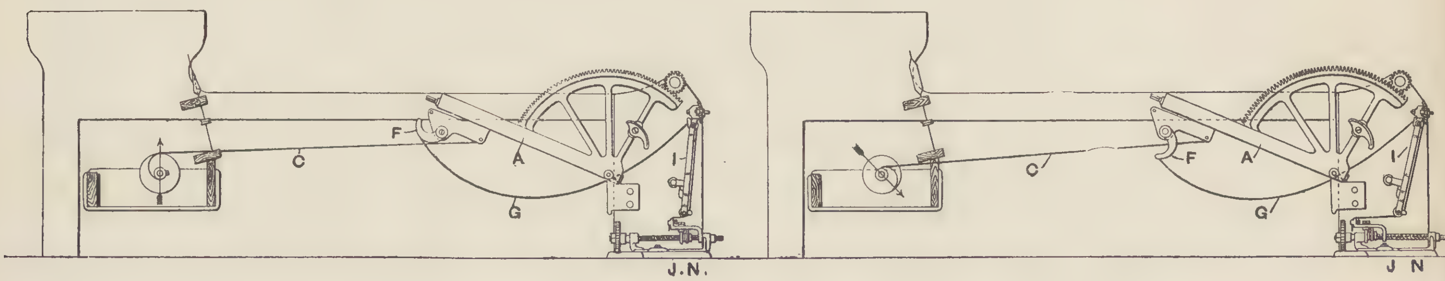
FIG. 169.

As was shown in paragraph 303, this causes a depression of the counter faller wire. This is utilised to revolve the quadrant screw and traverse the nut and slide. In other words, the winding is said to be "governed," and the motion is known as the "governing" or "strapping" motion.

(337) Fixed on the winding faller and counter faller shafts B B^1 (Fig. 168) are two arms U U^1, to which the ends of a light chain Y^1 are attached. The chain passes round a runner, or pulley, placed in the outer

end of the hinged lever Y, which is in this way sustained. It is obvious that the vertical position of the lever will be strictly regulated by the position of the two arms U U^1. As they follow the oscillations of the winding and counter faller shafts, the elevated position of these during spinning ensures the lever Y being raised at its free end. This results in the tooth, or detent, being taken out of contact with the teeth on the pulley S. When the counter faller is depressed by reason of the tension of the yarn upon it a similar movement occurs in the lever Y.

(338) In the early stages of winding, when the winding faller is depressed to a comparatively large extent prior to being locked, the vertical position of the lever Y is naturally lower than when the winding faller is not pushed down so far. It thus occurs that, when the cop bottom is being formed, which is the stage during which the traverse of the nut is required, and the winding faller is locked at its lowest point, the clearance of the detent catch on Y and the teeth on the pulley S is least. At this period, therefore, they are most easily engaged by any depression of the counter faller. When the higher initial velocity of the spindle, produced as described in paragraph 336, causes the yarn to be put into tension and the counter faller wire depressed, an engagement of the catch and pulley teeth occurs.



Figs. 170 and 171.

(339) The effect is that the rotation of the toothed pulley is stopped, and the band Q is practically gripped by S and its fellow pulley S^1, which are borne by the carriage. Instead, therefore, of slipping over the pulleys as before, the band is drawn along with the carriage and the remaining pulleys are caused to revolve. The force so applied is sufficient to rotate the grooved pulley P^1 by overcoming the resistance of the spring clip, and the bevel wheels and quadrant screw are rotated. The nut is thus moved outwards, and the winding chain relieved as previously described. This causes a slight diminution in the speed of winding, sufficient to relieve the pressure of the threads on the counter faller wire, which rises and breaks the contact of the detent and the toothed pulley. The further movement of the nut is thus arrested.

(340) The necessity for a diminution of the initial velocity of the spindle is strictly relative to the counts of yarn being spun. Some of the finer counts require a very slow traverse of the nut, and there may be practically none during several draws of the carriage. As the nut slowly rises and the locking point of the winding faller is elevated, the period of the engagement of the detent catch and the wheel S becomes

shorter, and the rotation of the screw is not so prolonged. When the cop bottom is fully formed, the nut is at its most outward point, and the "governing" motion is not therefore required. At this point, the relative positions of the arms U U^1 are such, that the chain Y^1 will not permit the lever Y to fall sufficiently to allow its tooth to engage with the wheel. The motion, therefore, falls out of use until the commencement of another set of cops.

(341) The motion of the winding scroll is communicated to the tin roller by means of a catch or "click" plate shown in detail in Fig. 168. On the spindle of the winding scroll X^1 is a spur wheel—indicated by dotted lines—which engages with a small pinion on the tin roller shaft T. The whole of this special mechanism is shown in longitudinal section in the right hand top corner of Fig. 168. The pinion is cast in one piece with the disc V which is loose upon the shaft T. The latter has a pin fixed in it, on which the small catch or "click" V^1 is hinged. The click catch is ordinarily held out of position by the bent spring W^1, which surrounds the boss of a ratchet wheel T^1—to which the name of the "click wheel" is given. When the "click spring" W^1 is slightly oscillated in the same direction as the rotation of the ratchet wheel, it allows the click catch to fall into gear with the click wheel. As the latter is keyed upon the tin roller shaft T, the engagement with it of the catch causes the tin roller to be revolved, and thus rotates the spindles.

(342) It was formerly the practice to allow the click catch to fall into gear when the disc V began to rotate upon the commencement of the inward run of the carriage. It was, however, found that the click catch engaged with the wheel earlier at one stretch than at another, and that, consequently, winding began a little more slowly than it should. The effect of such an occurrence is that a little slack yarn was produced as the carriage was running in, although winding was not taking place. Under these conditions tight winding at the nose throughout was practically impossible. It will be easily understood that, when the click catch is released, it may very readily be left either close to the tooth with which it has to engage or only just over the point of the preceding tooth. In the first case the engagement would take place at once, while in the second instance almost the distance of a tooth would have to be travelled by the click catch before engagement occurred. In hard twisted yarns this is especially objectionable, and its prevention is of importance.

(343) To overcome the defect thus explained a hanging lever W is fitted on the tin roller shaft, and the click spring W^1, instead of fitting on the boss of the disc V, fits on the inner boss of the lever W, which it clips. A slight oscillation of the lever is, therefore, at once followed by the movement of the spring, and the click catch is engaged. The tail end of the lever W comes in contact with a stop R^1 on the holding-out catch rod R. When R is moved in order to release the catch it causes the lever W to move into the position shown by the dotted lines, and so oscillate the spring W^1. The tail of the click spring passes between a fork formed in the click catch, and thus presses the catch in either direction, according to which side of the fork it gears with. When, therefore, the click spring is oscillated by the releasing movement of the holding-out rod acting upon the lever W, the click catch is forced hard up to the tooth with which it is engaging. The continued movement of the rod, if made, has, of course, no further effect upon the click catch,

but the parts are quite ready for winding with the click in gear. Immediately the carriage begins its inward run winding commences. Thus, whatever may be the position of the click catch at the end of an outward run, it is always ready for its work before the inward run commences. The weight of the rod W is sufficient to keep the click catch disengaged during the whole period of spinning and backing-off.

(344) The whole of the points relating to winding having been considered, the motions used in the fifth and last period require describing. When the carriage is near the completion of its inward run, the various parts are in the following position: The strap is on the loose pulley and the backing-off side shaft is being revolved either by the gearing named, or by its independent band; the back shaft clutch is disengaged and the back shaft is revolving so as to aid in drawing up the carriage; the rollers are disengaged and are not delivering roving; the taking-in friction is engaged, and the scroll bands are drawing in the carriage; the quadrant arm is completing its forward movement, and the spindles are revolving in their normal direction; the winding faller is locked and the wire is approaching the nose of the cop; and the counter faller is in contact with and sustaining the threads. As soon as the carriage arrives at the roller beam, the whole of these motions require changing, so that the different parts shall occupy the positions indicated in paragraph 286.

(345) This operation is mainly the work of the cam shaft, but in part is performed by other mechanism. As soon as the carriage arrives at, or near, the end of its outward run, the horn S^1 on the carriage comes in contact with the anti-friction bowl R^1 in the long lever T and depresses it (see Fig. 156). This removes the nose of the releasing lever from the raised surface on V and allows the friction clutch W X to come into gear. The cam shaft immediately begins to rotate, and the three cams to act upon the various parts in the reverse way to that previously described. The rotation of the cam Z (Fig. 156) performs the two functions of disengaging the taking-in friction clutch and engaging the back shaft clutch, the motions of these always being closely related. The cam W during the same period allows the roller clutch to go into gear, and the delivery of roving again begins. The rotation of the cam Y causes it to exercise a thrust on the pin fixed in G (Fig. 158), so forcing the driving strap over on to the fast pulley, this giving renewed motion to the spindles. The same movement causes the lever H to be pushed forward until the shoulder formed in it can again engage with the fixed catch L, the spring P pulling the end of H upwards as soon as it is sufficiently far forward. The strap guider is thus again locked when the strap is on the fast pulley. By the time these engagements and disengagements have been made, the cam shaft M has made its second half revolution, and the end of the release lever again presses upon the raised surface on the cam V and detaches the friction cone W from X. The cam shaft is thus stopped and remains stationary until the end of the outward run as described in paragraph 291.

(346) The whole of the parts governed by the cam shaft having thus resumed their original position, it remains to be shown how the winding and counter fallers are released, so as to be able to assume their relative positions out of contact with the yarn. The unlocking of the winding faller must be made as late as possible in the inward run, but the exact period at which it is made is affected by the height of the cop nose

on the spindle. The termination of winding requires to be made throughout the whole period of building a set of cops, at such a point as to leave sufficient yarn to coil on the spindles between their points and the cop nose. It will be easily seen that this quantity is varying throughout the whole of the formation of the cop, and that the length to be wound on is greatest at the commencement of the cop. This implies the unlocking of the winding faller at a point which is made gradually later, and this is well carried out in the Platt mule. At the lower end of the locking lever is a curved arm or "boot leg," which, at the termination of the inward run, comes in contact with the fixed stop bracket G (Fig. 161). The face of this is so shaped that the moment of unlocking is regulated in accordance with the requirements of the case throughout the whole of the formation of the cop. This is an important point, and requires careful attention. In a special form of mule, made by Messrs. Platt Brothers and Co., for finer counts, the stop bracket is a movable one, and is released by the run of the carriage, so as to slide forward and unlock at the exact moment required. The finer the yarns the more care is required in this respect, owing to their greater liability to breakage.

(347) Referring now to the release of the winding and counter fallers, it is essential that they should leave the yarn free as soon as spinning begins. For this purpose the lever J is raised by contact with the small roller W (Fig. 159), and its weight is removed from the counter faller shaft, and also from the winding faller. Still further to facilitate the descent of the counter faller, which is sometimes a little sluggish, a stop is placed in the headstock, which engages with a tail piece on the counter faller shaft when the carriage has run in. This arrangement is shown in the dotted lines at the right hand top corner of Fig. 161. The weight of the winding faller connections is, of course, sufficient to lift it quickly out of contact with the yarn.

(348) The operations thus described constitute the fifth period, and at its termination the mechanism is again engaged in the work of spinning or twisting, being at the commencement of another cycle of movements. There is, however, one more piece of mechanism to refer to before the description of this machine can be brought to a close. It was seen that during the period of winding the chain was drawn off the winding scroll during the forward stroke of the quadrant arm. Referring to Fig. 172, which represents a portion of the mechanism relating to the quadrant, it will be seen by the arrows that during the outward run of the carriage, the quadrant M also makes its backward stroke. During the same period it is necessary to rewind on the winding scroll the chain C which was previously unwound, and this is effected by the cord S. S is attached at one end to a hook or staple T, fixed to the framing, and at its other end to a weighted lever U, pivoted on a bracket fixed to the floor. The cord S, in its course, passes over the two pulleys shown fixed to the carriage, and its tension is sufficient to cause the pulley on the shaft X to be rotated by the inward run of the carriage, thus winding the chain C on to the scroll. By the termination of the outward run this operation is concluded, and the chain is ready to act again efficiently as soon as winding recommences. When a "set" of cops—that is, the whole number spun on a mule—is finished, it is "doffed" or stripped from the spindles. As soon as this is completed the winding nut is wound back by hand to the bottom of the quadrant, and the copping plates are also restored manually to their original position.

(349) The description thus given of the machine as made by Messrs. Platt will enable an accurate idea to be obtained of the mechanical movements which are found in the work of a mule. It is true that this special machine differs in some of its details from many of other makers, and that there are motions fitted to it which are not found in other machines. When the latter are used, however, they tend to increase the automaticity of the machine. The winding chain shortening, or, as it is more correctly called, the nosing motion, and the backing-off chain tightening motion, are of this class, both tending to an increased efficiency. The main principles in a machine of this class are embodied in the mule described, and the general explanations given will prove serviceable, whatever may be the make of mule studied.

(350) One of the important points of difference between this and mules of other makes is found in the position of the cam shaft. This, it was seen, is in the Platt machine placed above the axis of the rim shaft. In other cases it is placed, as shown diagramatically in Fig. 173, along the headstock of the mule, and below the centre of the long or "balanced" lever T. In this case the cam shaft K is a tubular one, and has passed through its centre the shaft M, which is suitably driven from one end. The cam shaft is fitted with a friction clutch at P, the fixed half being on the tubular shaft. The other half slides on the shaft M, being pressed up to the fixed half by the spiral spring

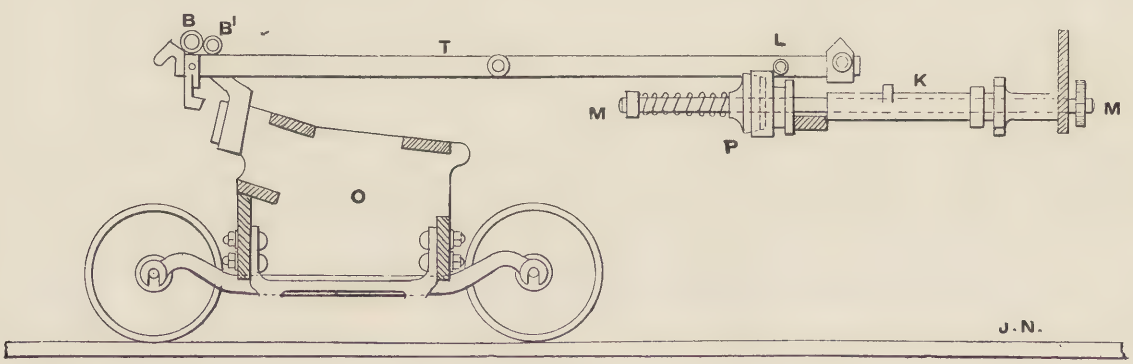


Fig. 173.

shown. On the long lever T at the point L a pendant cam plate is hung, which surrounds the cam shaft as shown in a detached front view and section in Figs. 174 and 175, and is formed with a slot so as to permit it to rise and fall freely. The cam plate has two raised cam surfaces or courses, against which the end of a pin is pressed by the action of the spiral spring. The pin passes through the half clutch fixed on the cam shaft, and presses against the sliding half on the shaft M. Thus when the pin is on the raised part of the cam plate the clutch is detached, while if it is on the lower part the clutch is in gear. When, therefore, the inner end of the balanced lever T is depressed, the fall of the pendant plate causes the pin to come upon the lower part of the cam course, and permits the engagement of the clutch. The cam shaft thus makes a half circle turn, and effects the necessary changes for beginning spinning. This causes the end of the pin to run on to the second cam course, and by the time the half revolution is made,

it comes on the raised surface and disengages the cam. In this position it rests until the outer end of the long lever is depressed, when a similar action occurs, terminating in a similar way.

(351) The back shaft is also engaged and detached in a different manner. It is driven from the roller shaft by a train of wheels, but the last of the train is a compound one, consisting of a large wheel with a smaller pinion. The latter gears with the back shaft wheel, and is put into or out of gear accordingly, as it is desired to revolve or

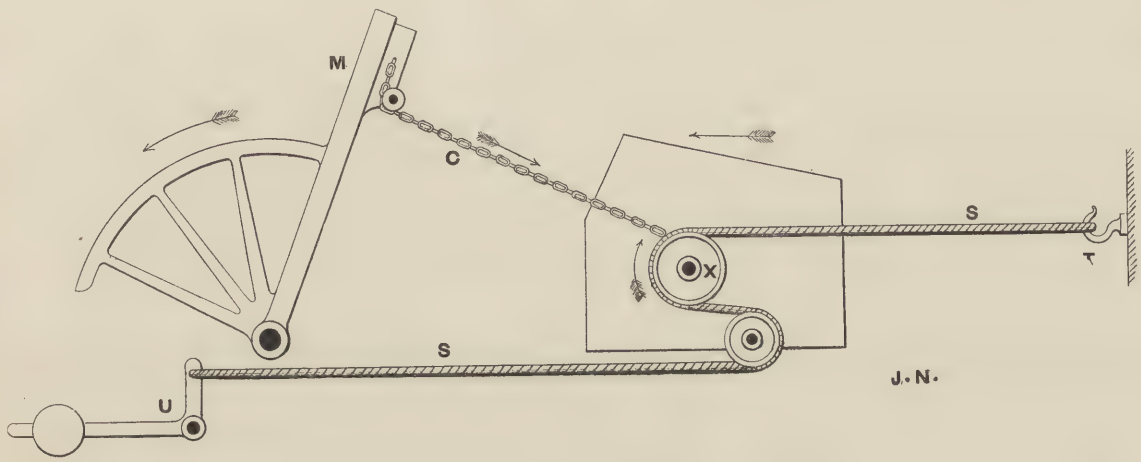


Fig. 172.

stop the rotation of the back shaft. For this purpose the compound wheel is borne on a hinged lever, called commonly the Mendoza lever, which is weighted in a suitable manner. The exact origin of the word Mendoza, as applied to this lever, is difficult to define, but it probably arises from the French phrase, *main douce*—Anglicè, the soft hand. However this may be, the function of the lever is to put the pinion into and out of gear with the backing-off wheel, and to effect this, its motion is controlled by a cam or eccentric on the cam shaft. This cam

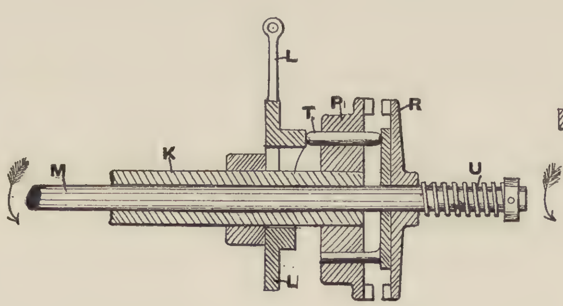


Fig. 174.

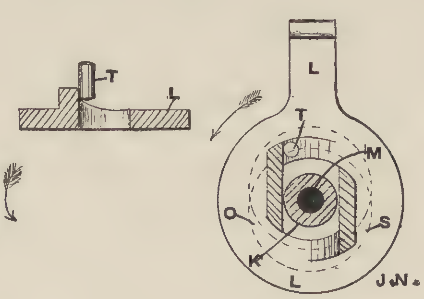


Fig. 175.

works in a fork in a lever, and the rotation of the cam shaft raises or lowers the Mendoza. The object of the weight is to ensure the full engagement of the pinion and back shaft wheel, so as to obviate any jumping out of gear at the commencement of winding. There is some tendency towards this unsteadiness of driving in the early part of the outward run, and it is desirable to lock the Mendoza lever in position.

(352) Messrs. John Hetherington and Sons employ a special device by which this difficulty is overcome. The mule, as made by them—arranged to be driven with the rim shaft transversely, instead of longitudinally, placed in the headstock—is illustrated in Fig. 176 in longitudinal elevation, and in Fig. 177 in back view. Both views show the method of driving quite clearly. On the outward end of the Mendoza weight a pin is fixed which takes into a fork formed at the upper end of a vertical lever. The fork is shaped with a shoulder or recess, below which the pin referred to can slip when desired to lock the Mendoza in position. A small ear is formed on the vertical lever, through which a set screw is passed, the point of which comes in contact with

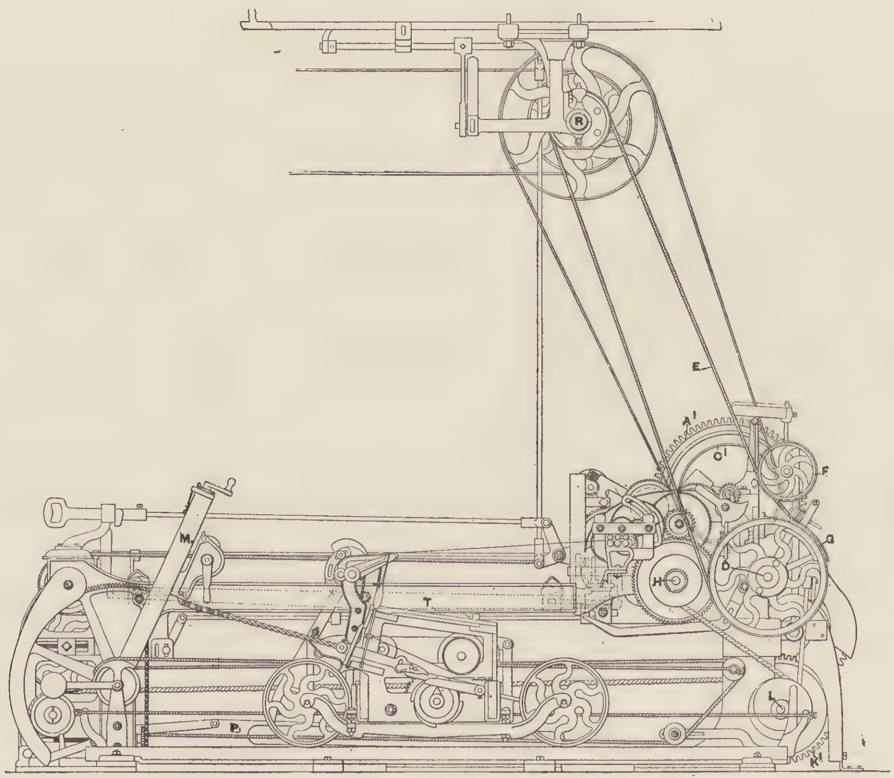


FIG. 176.

the end of a horizontal lever centred on a pin fixed in the headstock. The last named lever has a long tail extending outwards toward the carriage. When the carriage comes up to the back stops and the Mendoza lever falls, putting the driving pinion into gear with the back shaft wheel, the long tail of the horizontal lever is raised, and the effect is that the pin in the Mendoza weight passes under the shoulder of the fork in the vertical catch lever, and so firmly holds the Mendoza lever down. As the latter carries the driving wheel, the pinion is kept firmly in gear, and the effective driving of the carriage is obtained. As soon as the carriage has run out a little—by which time it has gained momentum—the horizontal lever is released, and

its long end falls, thus freeing the catch or pin in the Mendoza. Sometimes the minder, in cleaning, runs out the carriage a little and then changes the cam, without freeing the horizontal or locking lever. If afterwards the mule is started the carriage endeavours to run in, although the back shaft wheel and its driving pinion are in gear. This leads to breakages, and in order to avoid these, Messrs. Hetherington have arranged a small relieving lever, coupled to the long lever, so that any motion of the latter causes the

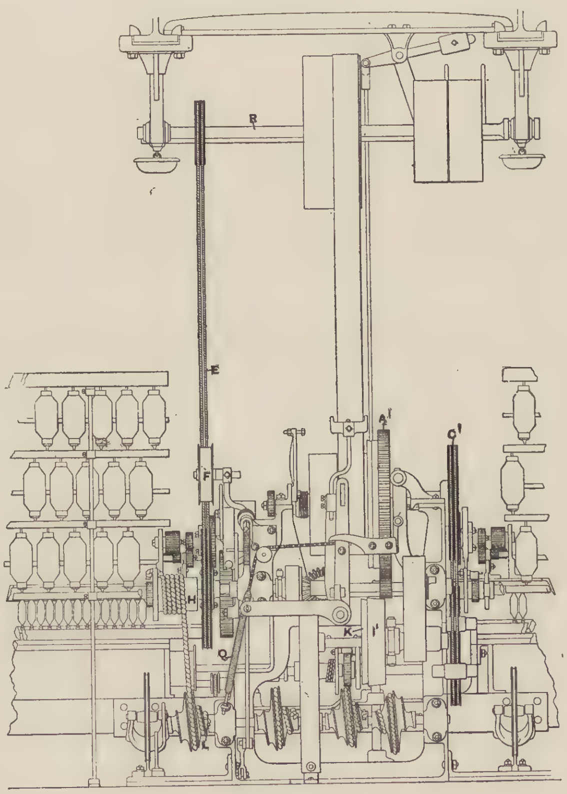


Fig. 177.

relieving lever to act and free the Mendoza catch pin, without reference to the position of the horizontal locking lever. This mule is arranged with the extra band for driving the taking-in side shaft D referred to in paragraph 286. The band E is driven from the counter shaft R, and passes round a double grooved pulley on D. It is kept in tension by the pulley F, carried by a frame which can be moved inwards by the quadrant rack G with which a worm gears. The remaining reference letters indicate the same parts as in the other illustrations.

(353) It was shown that to perfect the action of winding at the nose of the cop it is customary to deflect the chain by means of a nose peg. A motion based upon the principle of the deflection of the chain, but in which that object is attained in a different fashion, is shown in Fig. 178 in side elevation, and in Fig.

179 in enlarged detail. This is Dobson and Hardman's patent, and is made by Messrs. Dobson and Barlow. Two main objects have been aimed at. These are the control of the winding from the faller—so that the relation of the two will be strictly maintained—and the deflection of the chain by a pull from below instead of a push from above. On the faller shaft a tappet is fixed, to which is jointed a lever J with an arm or finger K secured to it. A bracket H is attached to the quadrant arm a few inches from its centre, and its outer edge H^1 is formed into a rack with which two catches engage. These are carried by a lever G, which is hung on a pin in the upper part of the bracket H. G has a projecting shoulder at its outer end, to which is fastened one end of the chain E passing over the pulley F, and having its other end attached to the lower end of the link C. The winding chain B is also attached to the link C. The lever G is formed with an arm G^1, to which is jointed a double tumbler I, each part of which is free to move as required. A projection is cast on I, which causes it to rest on G when in its normal position. This mechanism acts

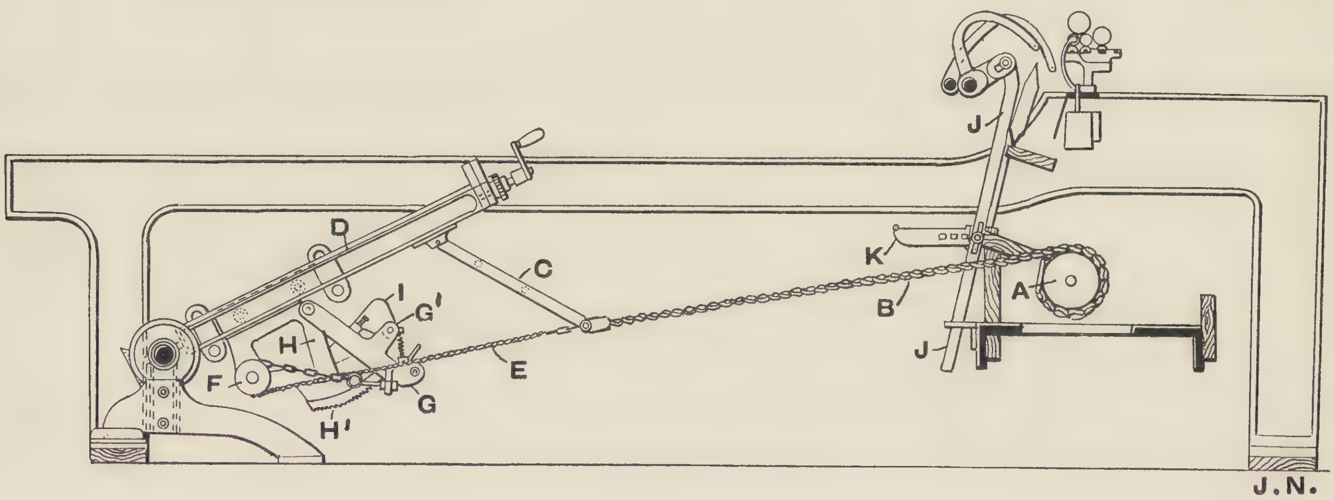


Fig. 178.

in the following manner: When a set of cops is begun the lever G is at its lowest position relatively to the quadrant rack H^1, and the winding chain B and link C are then almost straight. At the end of each stretch the finger K comes into contact with the lower part of I, which is raised to allow K to pass. When the inward run begins K causes the projection on I to press upon the lever G and raise it if the pressure is maintained a sufficient time. Whether this is so or not is determined solely by the vertical position of J, which, in turn, is regulated from the winding faller. If the latter is not substantially raised from stretch to stretch the position of G in like manner remains unaltered. If this is not the case G is a little lifted, and the chain E is thus drawn forward a little over the pulley F. The result is that a pull is exercised on the link C, which is drawn down so that it and the chain B no longer represent a straight line. This is equivalent to shortening the chain B, and the result is that the necessary acceleration of the winding

drum is effected. The chief feature of this motion is the regulation which is obtained from the faller, the position of which fixes the amount of extra *pull* put on the drum. However slowly the building proceeds the necessary acceleration is made in exact proportion.

(354) In the description of the governing motion, given in paragraph 339, it was shown that the rotation of the screw in the quadrant arm is made during the inward run of the carriage. There are some objections made to this procedure on the ground of the extra tension put on the yarn in the early part of winding, which is of some moment when fine or tender yarns are being spun. In Fig. 180 a side view is given of a motion made by Messrs. Dobson and Barlow, which is designed to obviate the necessity for altering the screw during the inward run, and provide means by which it can be made during the outward run. In

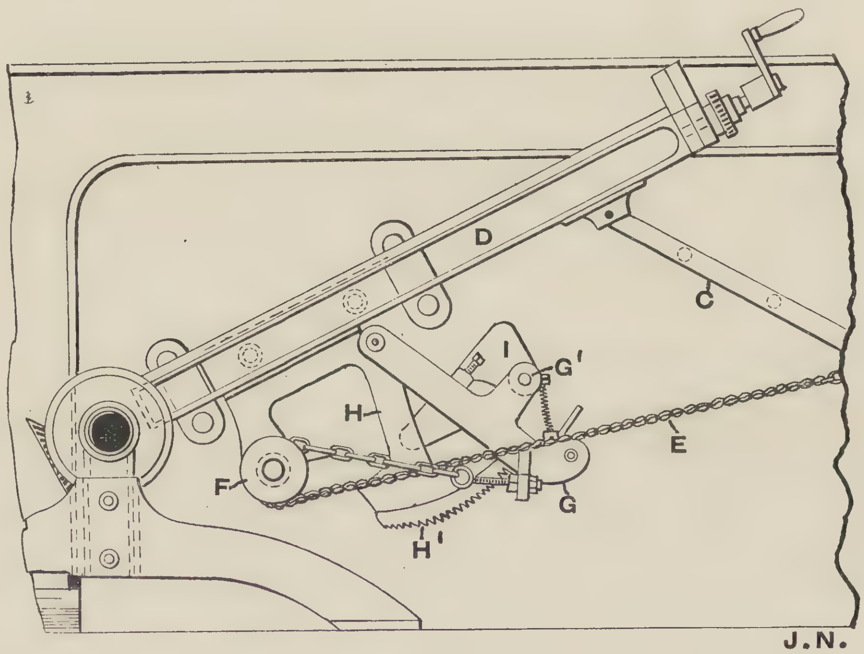


Fig. 179.

lieu of the ordinary grooved pulley on the quadrant axis, a toothed wheel U is used, with which a toothed rack R can engage under circumstances presently to be described. The rack R is carried by a sliding frame S, which is fixed upon a longitudinal rod T, extending backwards in the headstock, and carried by brackets fastened to the floor. The rack is fitted at one end with an inclined foot, and at the other with a spring, which prevents too deep an engagement of the rack and wheel. The rack passes—during its outward stroke—over a frame fastened to the headstock, in which is a screw X on which is threaded the sliding stop W. The pitch of the screw thread is varied to correspond with the thread in the quadrant arm Q, and the screw is rotated by a ratchet wheel, with which a pawl, oscillated by a finger, engages. At the point I a loose tongue is hinged, which at the end of the stroke of the frame engages with the nut W. On the winding faller

a sector Y is fixed, in which a stud, formed with two portions of different diameters, is bolted. On the counter faller a sector Z is fastened, carrying a screwed staple, to which is secured one end of a chain, indicated by dotted lines. The chain passes round the bowl R at the upper end of the pendant lever O, guided in brackets at the front of the carriage. The loose end of the chain is formed into a loop, which can be slipped on to either of the surfaces of the bowl in the sector Y. A hinged finger L is carried by a bracket on the rod T, and has a little range of movement in a circular direction.

(355) In beginning a set of cops the stop W is turned back to its proper position, which is determined by the size of the cop about to be spun. The frame S is then pushed forward as much as possible, and the chain is slipped on to the smaller portion of the bowl in Y. This allows the pendant O to fall a little, and its height subsequently is regulated strictly by the position of the fallers. During the outward run the horizontal arm P, which forms part of the pendant O, engages with the vertical projection on the frame S and causes it to move forward. The rack R being raised engages with the wheel U and rotates it, this movement being consequently communicated to the quadrant nut. Thus the latter is put into position for action during the next period of winding and any straining of the yarn is avoided. As the stroke of the rack is continued, the tongue I engages with the nut and causes the rack to drop out of gear with the pinion, and any further movement of the quadrant nut is avoided. It has been shown that the traverse of the latter is gradually diminished as the cop is built, and, in like manner, the inward motion of the stop W causes the engagement of the rack and pinion to be limited. This is a sort of "trip" motion very familiar to students of steam engine practice, and is well applied in this case. The slide S is drawn back into position by the engagement of the lower end of the pendant O with the finger L. A slight contact at first between these becomes a firm one by the backward movement of the finger when pressed upon by the pendant O, but it will be obvious that, if the latter is too high to move the finger L, the rack will remain untraversed until a sufficient depression of O takes place. It only remains to be said that once the nut W has been set at the beginning of winding, all that is required is for the minder to slip the loop of the chain on the right portion of the bowl in Y, and the motion acts automatically until winding is finished.

(356) A somewhat similar attachment has been recently introduced in France, and is the invention of Mons. Dubs. The author is informed by a trustworthy mechanician that the motion acts perfectly throughout winding, and it may, therefore, be well to give a brief description of it. As in the motion of Messrs. Dobson and Barlow, the regulation of the nut takes place during the outward run, and it is unnecessary to again detail the reasons for this course. The chief operating part of the mechanism is the rack finger A—shown in its position when in gear—which is hinged on a vertical rod or plunger K, sustained in a frame or bearing S fastened to the carriage. Referring to Fig. 181, the whole of the apparatus moves with the carriage and is self-contained. Attached to the faller is a connecting rod or link B, which is coupled to a hinged lever O formed at its outer end with a toothed rack or quadrant finely pitched. With this rack, which has two sets of stepped teeth, two detent catches H engage. The lever O is hinged to a plunger L, which has at its lower end a screwed shank fixed to a plate F also secured in the same manner to the

plunger K. The inner end of the rack lever A has a hanging piece D which can engage with a catch E on the plate F, but which in the view is shown out of gear. The downward motion of the inner end of A is regulated by the stop screw R, and it is coupled by the chain C to the counter faller. The spring M constantly presses the inner end of A down, tending to raise the rack. When the various parts are adjusted the parts F K and L move together and simultaneously with the lever O.

(357) The action of this mechanism is as follows: Assuming that the inward run of the carriage is nearing completion, the lever G engages with a stop or bracket fixed to the floor, which causes D to fall out of gear with the catch E. This leaves the plate F and all its connections to the control of the chain C and the

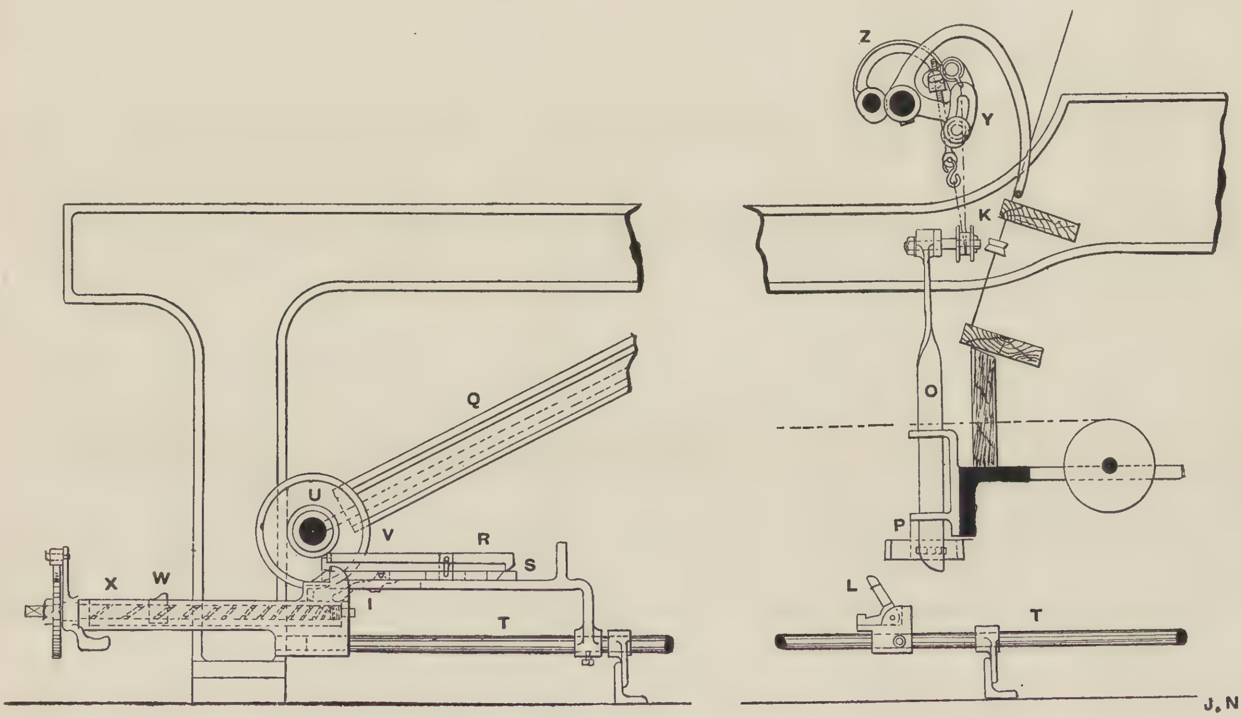


Fig. 180.

counter faller. When the faller locks it raises the rod B and the lever O, which is then held in position by the detent catches H. During the first inward run O is lifted to its highest point, which, of course, affects all the parts attached to it. Just before the end of each stretch the catches H are released, so that the whole of the subsequent regulation depends on the counter faller. As the locking point of the winding faller wire is gradually raised the elevation of the fork at the upper end of K—which by reason of the connection of the plate F with the lever O always takes place—occurs at a gradually lower point throughout building. The effect is that when D is released, as described, an elevation of the rack A takes place if needed. If not, D falls over the catch E as the carriage begins to run out and thus locks it, preventing the rack A from

rising. If, however, the tension on the yarn at the end of winding is such that the counter faller is depressed, the catch D cannot recover its position. The end of the rack lever consequently falls on to the stop screw R, and the rack is raised into contact with a wheel on the quadrant axis formed with teeth of a similar shape. Thus the screw is given a turn while the carriage is running out, and the nut is in the correct position for winding the next length.

(358) Quite recently Messrs. Curtis, Sons and Co. have constructed a mule in which the cam shaft, as an instrument for making the "changes," is entirely done away with. A side elevation of the mechanism for effecting this is shown in Fig. 182, and a plan of the same in Fig. 183. The back shaft clutch F is formed so that its driving half slides, this being controlled by the action of a lever L, connected, as shown, at two points to the rods R M. The taking-in friction is placed horizontally, and is controlled by the vertical lever H connected with the sliding rod R. The lever F^1, by which the back shaft clutch is disengaged, is coupled by the link going across the carriage—shown in Fig. 183—to the roller clutch box, so that the engagement or disengagement of the roller clutch box is simultaneous with the attachment or detachment of the roller gear. The mechanism for actuating these parts is based upon the principle of the push and pull of spiral springs, a partial application of which was shown in the case of the backing-off rod. On the axle of the quadrant a short arm S is fixed, which is coupled with the rocking lever T, connected to the sliding boss on the rod M. Two springs M^1 M^2 are threaded on the shaft, and are placed respectively between the sliding boss and stop hoops fixed on the shaft. The rod M is coupled at the back to the lever L, the function of which is, as indicated, to actuate the back shaft clutch. At the front end of the rod M a catch lever Q is fixed, which detains it as the carriage is running out. When this happens, the spring M^1 is compressed by the oscillation of the quadrant axle acting through the crank S and its connections, the other spring M^2 being then out of compression. As soon as the end of the outward run is reached a boss on the counter faller shaft B^1 comes in contact with the underside of the catch lever Q and raises it, thus freeing the rod M. The spring M^1 is thus free to extend, and, acting upon the lever L, disengages the back shaft and roller clutches. This accounts for one part of the changes; and while it is taking place a catch lever O, which had previously been raised, is lowered. When the inward run of the carriage is made by the operation of the same parts the spring M^2 is compressed. On the arrival of the carriage at the roller beam the lever O is tripped by a boss on the faller shaft B, allowing the spring M^2 to extend and re-engage the two clutches named.

(359) The taking-in or scroll shaft is operated from the rod R, which is fitted with one spring only at its back end. This is compressed by the intervention of a second lever, fastened on the same shaft on which the rocking lever T oscillates, the compression taking place during the outward run of the carriage. The spring is held in compression by a latch P, which engages with a lug on the rod R. When the carriage runs in, a boss on the faller shaft releases the latch, and the extension of the spring disengages the taking-in friction clutch. The latter is put into gear by the locking of the faller in the ordinary manner, and is held in gear until the latches O and P are tripped in the manner described. The spring R presses on

a collar carried by the lever H, and the releasing of the friction is aided by the lever L, which comes against the head of H when the spring M^2 is extended. The levers H and L are so arranged that they cannot both act together, so that the two motions of taking-in and drawing-out cannot be in action at the same time.

(360) The angle of the spindle relatively to the vertical line is such as is necessary to suit the material being spun, but there is another feature which it is necessary to mention. As the point of the spindle moves

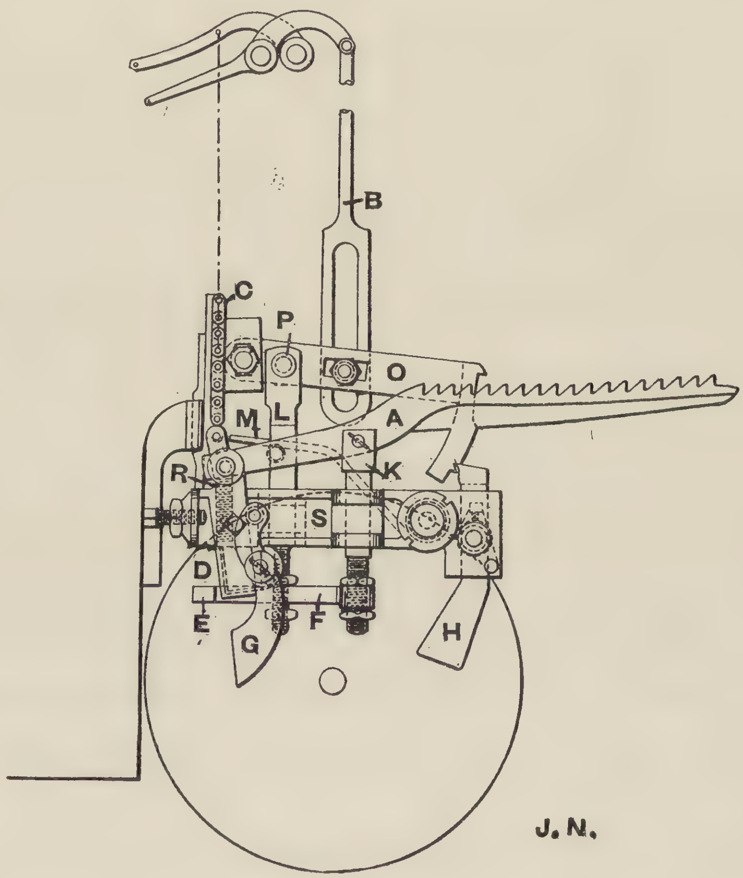
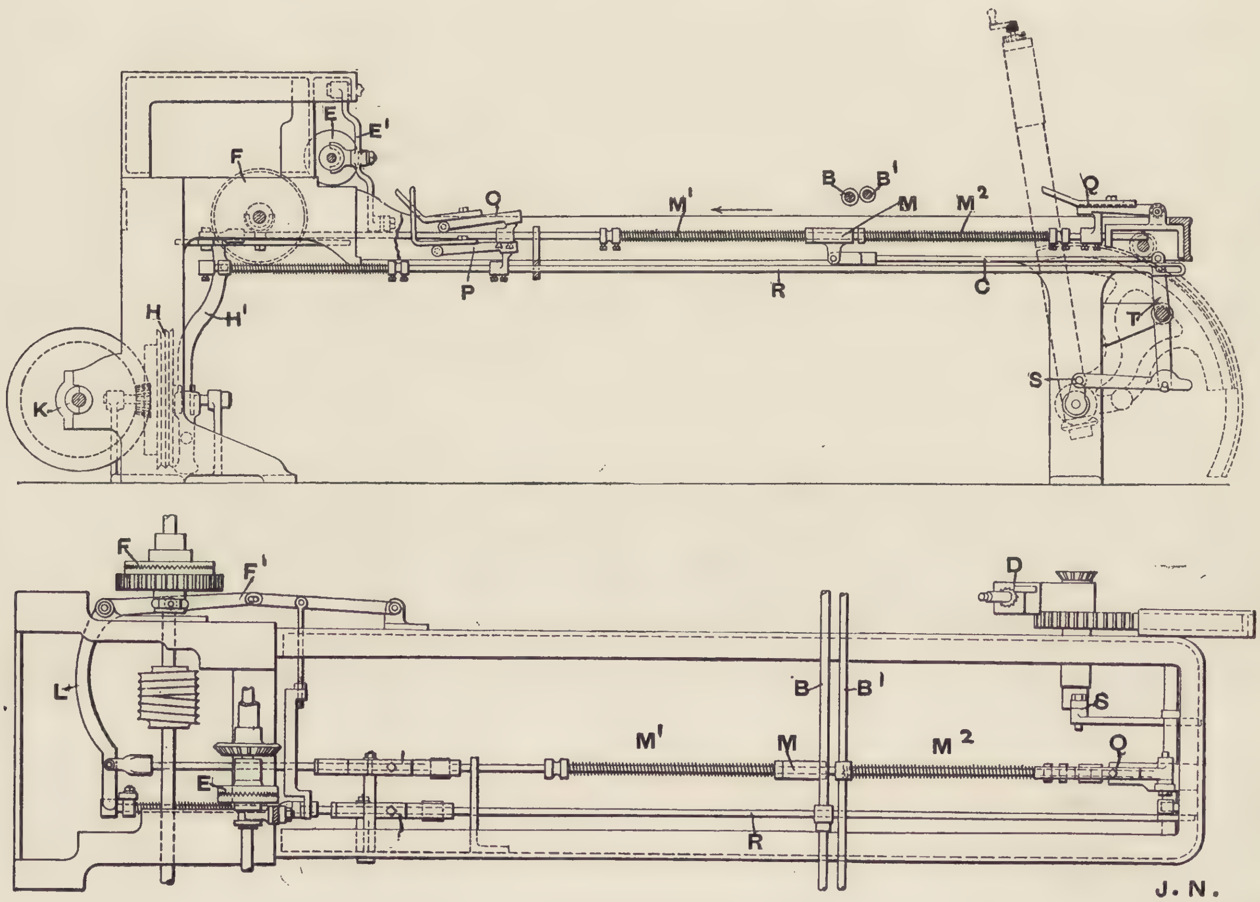


Fig. 181.

in a horizontal plane, it is obvious that the yarn will pass on to it from the rollers at an angle varying with its distance from them. That is to say, the angle formed by the yarn, in passing on to the spindle, will be more acute when the carriage is near to the rollers than it will be when it is further away. This has a little influence upon the problem of spinning, and an arrangement exhibited at the Manchester Jubilee Exhibition, applied to Messrs. Asa Lees and Co.'s mule, is shown in Fig. 184. In this case there are two carriage slips instead of only one, and these are inclined so as to compensate for the difference in angle. On one of the

slips A the front carriage runner D travels, and on the other the back one C. The result is that the inclination of the spindles is slowly altered, with the result that the angle formed by the yarn and the spindle in each case, is nearly the same in all positions. This device worked well, but the difficulty existing does not appear to be great enough to lead to any wide adoption of it.

(361) Having thus described in detail the construction and principles of the mule, it is only necessary to say a few words on the subject of its application to the spinning of the finer counts, which require specially



Figs. 182 and 183.

delicate treatment. It is found necessary to fit a few special attachments which are supplementary to the ordinary mechanism employed. In dealing with fine yarns the rollers are stopped a little before the carriage has completed its outward run, and this results in the yarn being a little stretched. A more important result, however, is that if there be any unevenness in the diameter of the yarn, the twist speedily runs into the thin places, which become hardened, and do not easily elongate or draw. The thicker places remaining untwisted are, therefore, drawn down until the full twist runs into them also. This supplementary twisting

and drawing is called "jacking," and its amount varies, of course, with the staple of the cotton being spun, the further movement of the carriage being sometimes as much as five inches. In order to permit the jacking to be effective, it is the custom to put into the yarn very little twist before the roller delivery ceases, after which it is rapidly introduced. This tends to shorten the yarn and puts it in such a state of tension, that unless relieved, it would break. There are two methods of obviating this difficulty. The first is to move the carriage in a little during the period of twisting, and the other to cause the rollers to deliver a short length of yarn. The latter is now the most usual method, and by the adoption of a special engaging motion, the amount delivered can be regulated at will. When long stapled cotton is being spun, it is the practice to cause the rollers to deliver a little yarn during the inward run, while winding is going on. The amount varies, but is about three inches, so that only 60 inches is wound on the spindle during each inward run. Messrs. Platt Brothers and Co. make a very good fine spinning mule with a number of well thought out motions of great ingenuity, a full description of which will be found in the Proceedings of the Institution of Mechanical Engineers, 1880, pages 516 to 527.

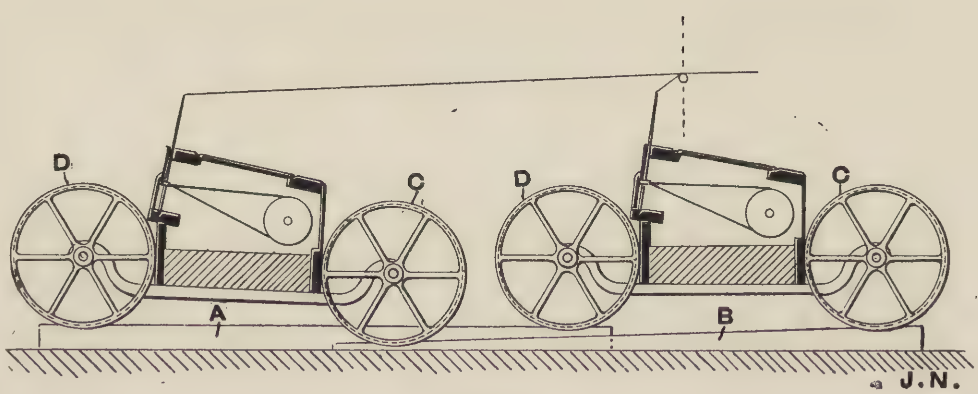


Fig. 184.

(362) Mr. Richard Threlfall of Bolton has devoted himself to the construction of fine spinning mules, and has produced a self-acting machine, which is capable of spinning the highest counts. With a brief description of it as made by him, the present treatment of this machine must be closed. In the Threlfall mule the roller delivery after jacking is effected by a short shaft on which is a catch box, the outer surface of which constitutes a cam course, which is revolved from the twist shaft. On this cam shaft is the first of a train of wheels, which gear up to the roller, and the first wheel has motion given to it by a ratchet and pawl, the movement of the latter being controlled by the throw of the cam. The cam can be set so as to give a whole turn to the rollers, or only one flute, and by means of changes in the train of wheels further regulation can be made. The copping rail is specially constructed, so as to enable short cops of any shape to be easily built. The fallers are arranged so as to be very sensitive in action. The action of the quadrant is aided by a special contrivance consisting of a narrow pulley placed alongside the loose

backing-off pulley, but fast on the shaft. Connected to the strap guide is a lever which is coupled to a rod suitably carried in brackets, and on which is a regulating screw and nut. This regulation is provided so that the passage of the strap on to the narrow pulley is effected as desired. The strap is prevented from traversing from the loose pulley by a catch, and the release of the latter is effected by a finger on a bracket fastened to the carriage square. When the latter runs in the finger pushes over a tumbler holding the catch in position and releases the latter. The weight of the parts then throws the strap over on to the fast narrow pulley, and the winding is thus accelerated. By fixing the finger and setting the adjusting screw, this motion may be brought into play at any desired moment. On the faller shaft is a bracket, to the outer edge of which is attached by a bolt or screw a grooved cam surface. To this is attached a cord actuated by the governor motion. By suitably setting the cam, winding is effected during each inward run with equal tension. A brake is applied to the faller shaft, consisting of a lever fastened to the carriage, one end of which engages with an inclined plane, and the other end has a cord attached passing over a pulley on the faller shaft. By tightening the band the faller is held perfectly steady. The combination of the last three motions effectually prevents snarls. A roller delivery motion is added, and the most perfect adjustment of the whole of the movements is provided. The spindles revolve at two speeds, the final or twisting velocity being about 8,000 revolutions per minute.

(363) Such is a description of the most intricate machine in the whole range of textile mechanics, which, although threatened more than once with extinction, is yet more largely used to-day than at any previous time. On it yarn of varying qualities can be spun, either soft or hard twisted. The yarn which is used for warp purposes is more commonly known as twist, and that employed for weft is known by that name. Weft yarn, as will be shown at the end of the next chapter, is always more softly twisted than warp yarn, and the mule spindles revolve in the opposite direction to that employed when the latter is spun. About the question of twists and the system of the arrangement of draughts throughout the whole process of spinning, a few words will be said in concluding the next chapter.

(364) The mule is used in a modified form to produce "doubled" warps—that is, two strands of yarn twisted together. When so employed, the machine is known as a "twiner," and is constructed with a low creel. With the necessary alterations to suit the circumstances peculiar to the case, the machine is largely employed in certain districts. In its main features, however, it resembles the mule, and does not require a detailed description. Another modified form is used for spinning yarns made from waste, being nearly identical with the machine as employed in spinning fine worsted yarns. The student who is interested in this subject will find a description of the woollen mule in "Spinning Woollen and Worsted," by Mr. W. S. Bright M'Laren, M.A.

(365) A table is appended of actual productions from Messrs. John Hetherington and Sons' mule. These are given from 74 machines for the ordinary working week of 56½ hours. A great variety of counts are included, all of which were being spun at the same time. An additional table is given of productions from Messrs. Platt Brothers and Co.'s mule. An explanation of the value of the hank is appended to the next chapter.

TABLE 2.

ACTUAL PRODUCTIONS IN A WORKING WEEK OF 56½ HOURS, FROM MESSRS. JOHN HETHERINGTON AND SON'S MULES.

No. of Mule.	Hanks.	Counts.	Hanks per Spindle.	No. of Mule.	Hanks.	Counts.	Hanks per Spindle.
2	77,250	39	31·14	40	62,000	38	30·21
4	70,750	43	28·52	42	58,500	38	28·50
6	71,000	43	28·62	44	62,750	36	30·57
8	75,500	41	30·44	46	62,250	38	30·33
10	65,750	32	32·42	48	63,250	36	30·82
12	68,750	28	33·90	50	60,250	38 } 33 }	29·35
14	61,750	36	30·44				
16	71,750	45	28·73	52	64,750	34	31·55
18	69,750	45	27·94	54	65,750	36	32·03
20	72,250	45	28·94	56	65,000	40	30·52
22	71,750	45	28·73	58	61,750	40	29·91
24	71,000	45	28·43	60	61,000	42	29·55
26	71,250	45	28·53	62	60,000	42	29·06
28	71,250	45	28·53	64	63,000	40	30·52
30	72,250	45	28·93	66	61,500	40	29·79
32	73,000	42	29·23	68	61,500	42	29·79
34	72,500	42	29·03	70	61,250	42	29·67
36	61,500	36	29·97	72	59,750	42	28·94
38	66,750	32	32·52	74	65,750	40	31·85

Total Weight, 59,920½ lbs. Average Counts, 39·53. Average Hanks per Spindle, 29·88.

TABLE 3.

ACTUAL PRODUCTIONS IN A WEEK OF 56½ HOURS OF TWIST AND WEFT YARNS FROM MESSRS. PLATT BROTHERS AND CO'S. MULES.

TWIST.			WEFT.		
No. of Spindles in each Mule.	Counts spun.	Hanks per Spindle.	No. of Spindles in each Mule.	Counts spun.	Hanks per Spindle.
1044	30's	32	1280	28's	33·81
"	32's	31·5	"	29's	34
"	33's	30·65	"	34's	31·85
"	34's	30	"	36's	31
"	50's	28	"	38's	30·46
"	54's	27	"	40's	30
			"	46's	29

NOTE.—The production of any mule varies of course with the class of cotton used, the amount of twist required, and the length of mules; but the figures given in the tables are, in each case, figures of actual productions.

CHAPTER XII.

THE RING SPINNING MACHINE.

(366) The term Ring Spinning is applied to that process by which yarn is spun by means of a machine in which a spindle, revolving in the centre of an annular ring, is used. The ring is formed with a flange or bead over which a C shaped clip or "traveller" is sprung, being drawn round the ring by the yarn during the revolution of the spindle. It is from the use of such a "ring" that the system has been named. The difference between mule and ring spinning is mainly that between continuous and intermittent work. The ring frame is the successor of the throstle, as it was called, in which the twisting was conducted by the aid of a two-armed flyer, formed with a curl at the end of each arm, through one of which the yarn passed on its way to the bobbin. The flyer was fixed on the end of a vertical spindle, and the bobbin was superimposed on it, resting on a rail having a reciprocal traverse, flannel washers being placed between the flange of the bobbin and the rail to give the necessary drag to the bobbin. Generally, the principle of the throstle is similar to that of the roving frame, when allowance is made for the fact that the bobbin is not positively driven. As it is not now in extensive use it is unnecessary to describe it in further detail, but its general construction can be easily understood if a spindle and flyer be substituted for the spindle and ring in the succeeding description.

(367) Referring now to Figs. 185, 186, and 187, the mechanism will be easily understood, and, as described, is common to most machines made at present, the illustrations being those of the machine as made by Mr. Samuel Brooks. Fig. 185 is a front, Fig. 186 an end view, and Fig. 187 a transverse section of the machine. A detached and enlarged view of one spindle and its necessary roller stand and lifting mechanism is given in Fig. 188. The roving bobbins B are placed in a two-height creel, and are conducted to the three lines of rollers carried by the stand A. From the front roller the roving passes through the wire eye E, fixed in a wooden board known as the "thread board," to the ring F, which is held by a suitable clip on a rail extending the length of the frame, and known as the "ring rail." The thread boards are hinged, and can be simultaneously thrown up by the levers I and their connecting rods, which are worked from the end of the frame. The spindle C is, as shown, self-contained, and is fastened into the "spindle rail" G by a nut. The top rollers are weighted by a stirrup, lever H, and weight M, ordinarily but not invariably. The spindles are driven by bands from the tin rollers in the centre of the machine, and the cop or spool is built by the reciprocal traverse vertically of the ring rail. The ring is approximately of the section shown in Fig. 188, and has slipped on to it the traveller. Without stopping to inquire at present the precise action of the latter, it is sufficient to say that the yarn is passed through the traveller on its way to the bobbin, and it is

evident that as the ring is raised or lowered the yarn will be wound on the corresponding portion of the spindle. Specially referring now to Fig. 186, the vertical reciprocal motion of the rail G is obtained from the cam E, which is keyed on the same shaft as the wheel D, driven by the worm A, which derives its motion from the main shaft. Each revolution of E depresses the lever in contact with it, the weight of the ring rails and their attachments

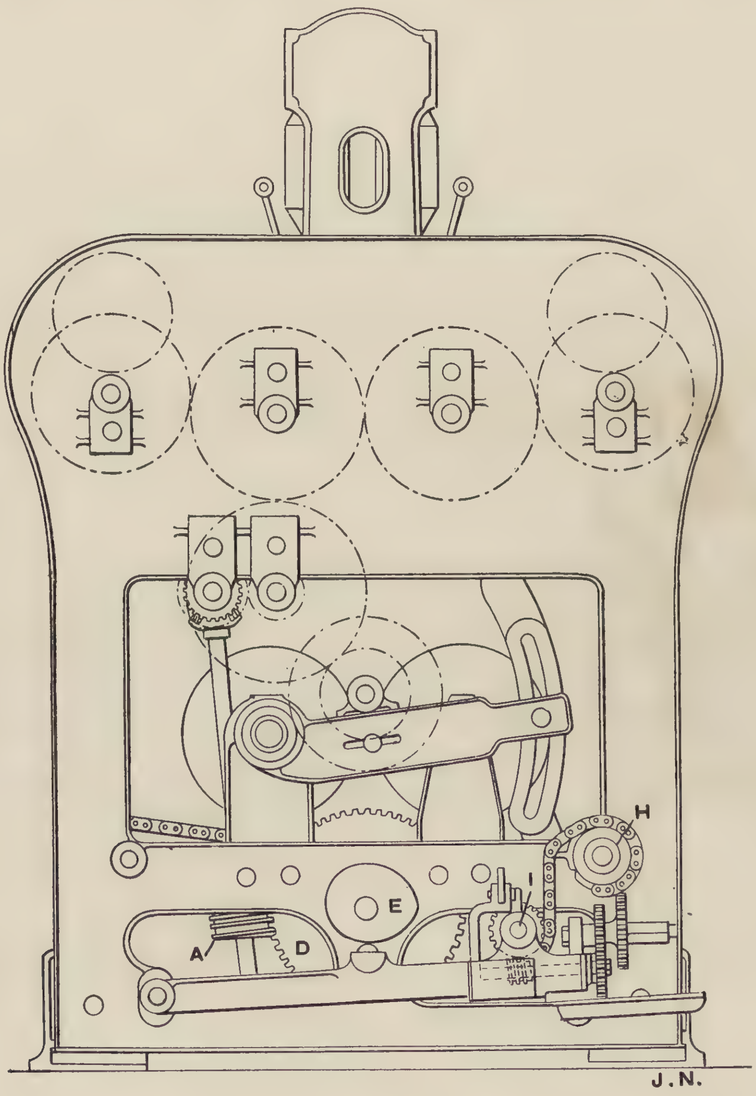


Fig. 186.

keeping the cam and lever in contact. The chain attached to the axis of the wheel D is thus unwound from a pulley, which being fixed on a longitudinal shaft causes the latter to rotate. On the shaft small pulleys H are keyed, to which the ends of chains, the other ends of which are attached to the lower ends of vertical rods or "pokers" sustaining the ring rail, are fastened. It is a common practice, instead of using

this chain arrangement, to key levers on the shaft, the free ends of which come under the feet of the pokers. An arrangement of this character is shown in Fig. 202. The rotation of the shaft obtained in the manner described raises the ring rail, the descent being obtained by gravity, but is regulated as to speed by the shape of the cam E. As this reciprocal movement is only about $1\frac{3}{4}$ to 2 inches, while the length of the cop

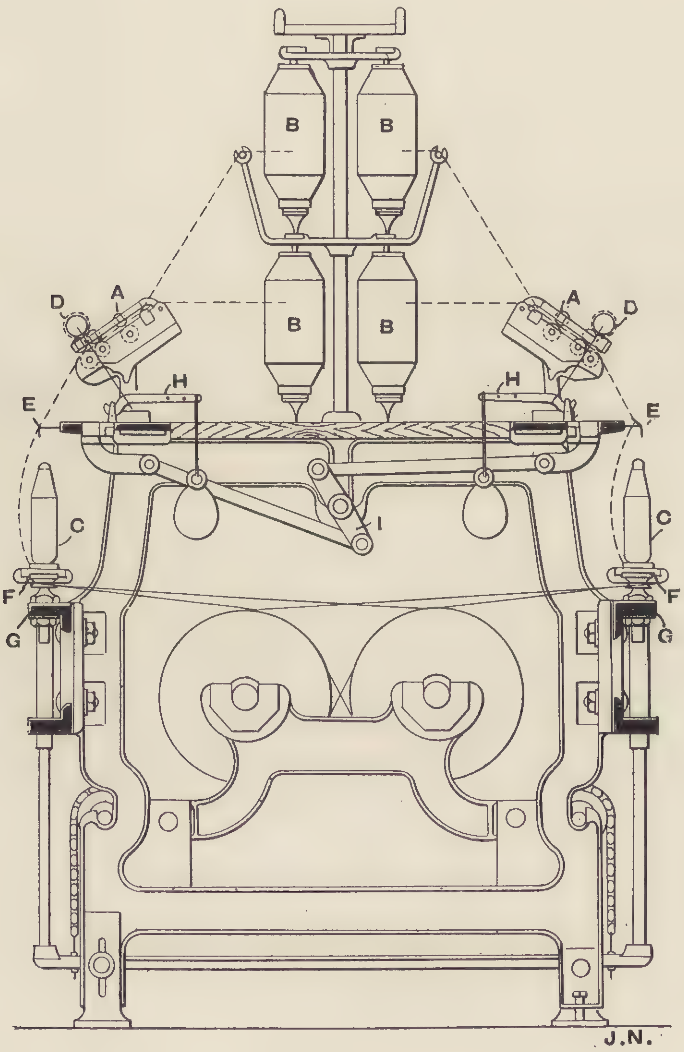


FIG. 187.

or spool spun is five or six inches, it will be seen that the ring rail must be slowly raised and a fresh starting point at each lift of the rail be obtained. This is effected by means of a ratchet motion automatically operated by the rise and fall of the lever. The rotation of the ratchet wheel is communicated through a train of gearing to the wheel I, and the chain connecting I and H is thus wound on to the former and from the latter. In this way a limited rotation of the shaft to which H is attached is effected, and the lift of the

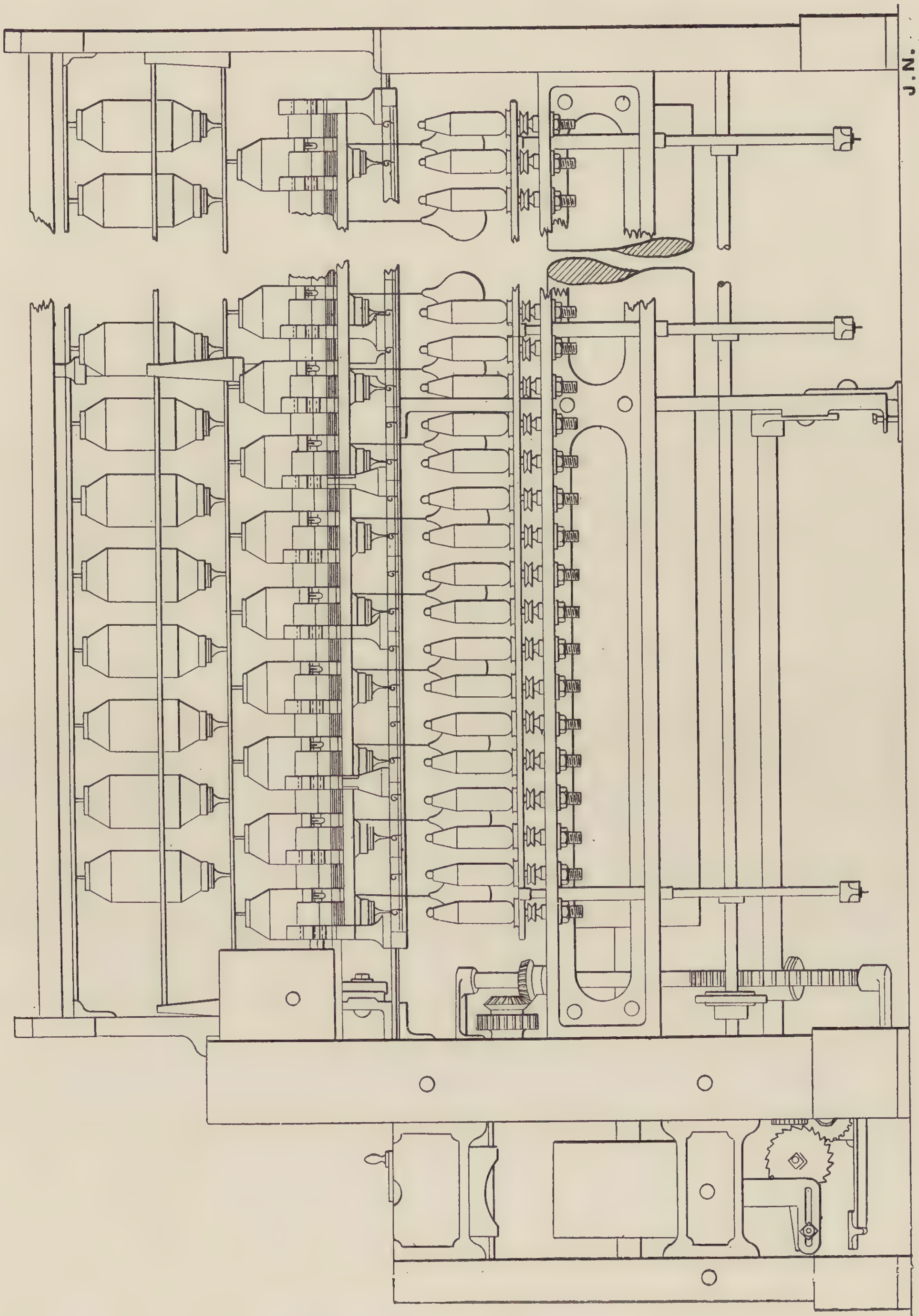


Fig. 135.

pokers commences gradually at a higher point. This elevation of the ring rail is of course a very slow one, but it is always taking place, and the result is that a thoroughly well built cop is obtained.

(368) The history of the ring frame is interesting, and keeping in mind the fact that a stationary annular ring is an essential feature of a machine of this description, no earlier date than 1828 can be assigned to it. In that year a patent was granted in the United States to one J. Thorp, who invented a ring somewhat resembling that in Fig. 201. The ring was in two pieces, and a groove was thus formed in which a solid hoop was placed. The yarn was conducted between the two rings, and was drawn round the periphery of the hoop by the pull of the spindle. In the next year a patent was taken out in the United States by Messrs. Addison and Stevens, in which the first mention is made of a traveller. The first patent taken out in this country was by Messrs. Sharp and Roberts in 1834, the next by C. de Bergue in 1836, and after that by J. G. Bodmer in 1837. In 1847 Messrs. John Platt and Thomas Palmer took out letters patent for spinning cops on a spindle similar to a mule spindle by the aid of a ring and traveller, a task which is not even yet accomplished. After this date nothing was done in this direction for some time, and inventors in this country appear to have dropped the subject, while in America it received much greater attention, and was finally brought to a successful conclusion there.

(369) In the year 1866 Messrs. J. and P. Coats and Messrs. Clark and Co., both of Paisley, and both having mills in America, introduced into this country short sample ring frames for the purpose of twisting sewing cottons, and in February 1867, Messrs. J. and P. Coats ordered from Messrs. P. and J. Mc.Gregor, of this city, eight sample frames of 238 spindles, each for doubling purposes. In May of the same year Messrs. Clark ordered from the same firm a sample frame, and during that and immediately succeeding years many repeat orders were executed by Messrs. Mc.Gregor. Messrs. Wm. Higgins and Sons, of Salford, also made machines on the American pattern for the same firms, and for the United States. In June, 1867, Messrs. Mc.Gregor made for Messrs. Knowles, of Burnley, a ring *spinning* frame, all those previously referred to being for doubling, and in October, 1869, they made for Messrs. John Dugdale and Bros., of Lowerhouse, near Burnley, fourteen frames of 364 spindles each. The author is not aware of any earlier actual use in this country on a large scale of ring frames either for spinning or doubling. At the latter end of 1872 Mr. James Blakey, a representative of Mr. Samuel Brooks, paid a visit to the United States, and there investigated closely the use which was being made of the machine. It is extremely probable that shortly before this time accuracy of workmanship was being better attained in the manufacture of these frames, and at any rate the *renaissance* of this as a spinning machine began about 1866. Mr. Blakey very fully studied the machine in its original home, and he became so imbued with a belief in its possibilities that he advocated its modern use with great earnestness to Mr. Brooks, who, being convinced of the future success of the machine, began its manufacture with considerable energy, and soon established a large business in it for doubling sewing threads. It was not however until the difficulties arising from the use of the ordinary spindle were overcome that the machine became unequivocally successful. This special point need not now be enlarged on, as it will subsequently be dealt with in detail. It is worth noting, however, that the first extensive use made of these frames was for doubling and not for spinning.

(370) The general description and history of the machine just given will convey a fairly accurate idea of its development, and the details of the machine can now be dealt with. The drawing rollers being common to all spinning machines no further description than that given need be furnished; but a reference to Fig. 188 will show that the roller stands, the thread board mechanism, and the relation of the spindle and ring are the chief points requiring explanation. It will be convenient, therefore, to consider these details in their order, and afterwards to deal with a few special points arising. As will be noticed, the roller brackets A are formed so that a line drawn through the axes of the rollers is at an angle with the horizontal. This has been found to be absolutely essential in order to obtain good work, and for this reason. It has been noted, and is well known, that the number of turns per inch put into the yarn depends on the relative speed of delivery of the rollers, and the revolution of the spindle. Now, in order to ensure that the twist shall be put in the entire length of yarn from the spindle to the rollers, it is essential that no portion of it shall be held in any way by any part of the mechanism, but should be quite free to receive the twist from the spindle to the nip of the front rollers. But if the rollers were in a horizontal plane, a certain portion of the yarn would be pressed against the bottom roller for about a fifth of its circumference. This is detrimental, because the twist cannot run up to the nip of the rollers, but is remedied by giving the roller stand the inclination referred to. In a lesser degree the same evil arises if the yarn passes through the wire eye E in the thread board at too acute an angle. To obviate this, it is now the practice to adjust the brackets A so that the nip of the front rollers is almost vertical to the spindle. The amount of the inclination of the roller stand varies according to the class of yarn to be spun, and whether the rollers are self-weighted or are pressed downwards by saddle and weights. If, for instance, weft is being spun, the number of turns per inch being less in this way than in warp or twist, and the yarn being correspondingly softer, the inclination is about 35°, while in the case of twist it will vary from 25° to 35°. Different makers alter this inclination to suit different requirements, and there are variations existing in it from 5° to 35°, but the angles given are usual ones. The thread boards are arranged, as described, to be lifted simultaneously by means of a lever, this being necessary when the frame is being doffed or stripped of its bobbins when the latter are full, the doffer being thus enabled to give a straight lift to the bobbin and avoid any straining of the spindles.

(371) The chief feature is, however, the relation of the spindle and ring to each other, and their special construction. It is essential that the spindle should be so fixed in its sustaining rail as to be truly vertical, and when its construction is dealt with it will be seen how perfectly this is obtained. The ring must be attached to the ring rail so as to be absolutely concentric with the spindle, and on the actually efficient performance of this duty depends very largely the success of the machine. Bearing these two points in mind, it will be convenient to deal first of all with the special construction of the spindle. As would naturally be expected, the first form used for this purpose resembled a throstle spindle without the flyer, or a mule spindle, but eventually the shape adopted generally was that which is shown in Fig. 189, the bobbin being also very light. A good many modifications took place, but in every case the bobbin was pressed on to the spindle above the top bearing or bolster. In 1870,

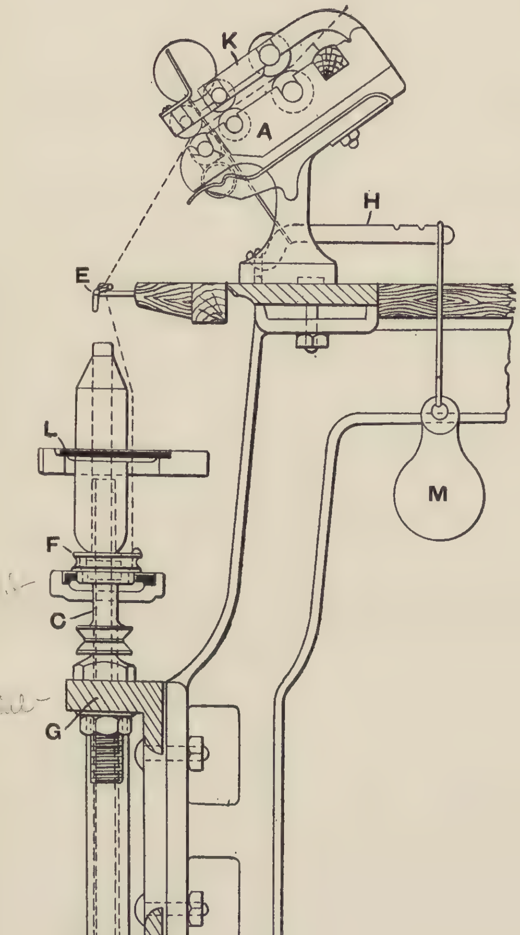
however, Mr. J. H. Sawyer, of Lowell, Mass., patented the spindle bearing his name, and which was introduced into this country under the name of the "Booth-Sawyer." The main principle of this form was the provision of a means by which the top bearing was carried up inside the bobbin B, thus sustaining it at a higher point than had been before possible. Referring to Fig. 190 the bolster A is formed as a hollow tube extending upwards from the rail, and having at the upper end a phosphor bronze bush, which acts as the bearing. A spiral groove is formed in the bolster by means of which the oil, being fed at C and held in the chamber D, is carried upwards so as effectually to lubricate the spindle. Special provision is made for the footstep, and both bolster and footstep are supplied with covers. The Booth-Sawyer spindle is beyond doubt an efficient one, and constituted a very great advance on those previously used. The position of the top bearing was higher than in any previous form, and it does not require any long comment to demonstrate the value of this improvement. It must be noticed, however, that it is necessary to oil every day, and that there are two bearings which are fixed in rails quite independently of each other. In spite of these defects, however, the Booth-Sawyer spindle has done, and is doing, excellent service in this country and elsewhere, and so far as output is concerned, is quite equal to any other spindle in the market.

(372) As has been previously stated, the most essential point in the successful construction of a ring frame is the preservation of the exact concentricity of the spindle and ring. If this is destroyed a very detrimental effect is produced, and it does not need to be pointed out that where there are two bearings to a spindle each of which is attached to a different rail, the difficulty of preserving a correct vertical alignment is very great. For these reasons the introduction of the Rabbeth spindle into this country by Messrs. Howard and Bullough about the year 1874 led to its wide adoption, and the practical supercession of the Sawyer, and gave a great impetus to this system of spinning. The principle of the Rabbeth is that of the Sawyer so far as the position of the upper bearing is concerned, but it has the further merit of being entirely self-contained. The latter feature was not new in the annals of British invention, but it was never thoroughly worked out nor made a success in this country until the firm just named took up the Rabbeth spindle. Students who desire to take up the history of this subject, can refer to a patent granted to William Wright in 1836, and also to one obtained by David Cheetham in 1857. The Rabbeth is entirely self-contained, its construction being that illustrated in section in Fig. 191. The spindle B revolves in a case or bolster C made of cast iron, which acts as a bearing for the spindle both at its upper and lower portions. The bolster is formed with a flange, as shown, and is accurately turned and bored all over. It has its shank screwed with a fine thread, so that when passed through the hole in the spindle rail, it can be firmly fixed in position by the nut shown. As the underside of the flange is quite square with the hole in the bolster, it follows that the spindle rail being planed on the top, the bolster case C will be in a perfectly vertical position. The spindle B is borne by a bronze bush at C, and by the footstep at F, the case being recessed so as to form a chamber containing such a quantity of oil that the necessity for lubrication more than once in six months is obviated. Fitting on the spindle is a sleeve with a warve or grooved pulley at its lower end as shown at E, the sleeve being bored with a conical hole and being tightly pressed on the spindle. The driving band passes round the warve and thus rotates the sleeve and consequently the spindle. A brass cup D is placed on the lower part of the sleeve, into which the foot of the bobbin is pushed, the upper part fitting the spindle as shown at A. In this

way the bobbin is positively driven, and the pull of the band being low down, the spindle can be run at a high speed with great steadiness. The sleeve is prevented from lifting by the hook G, which is carried in a small specially balanced frame suitably pivoted so as to allow of the sleeve being removed easily when required. This device is a patented one of Messrs. Howard and Bullough's, and is one of the best for the purpose. Various modifications of the Rabbeth spindle have been made, including the Dobson-Marsh, which provides for a readier means of oiling by taking off a cap at the lower end of the spindle and thus allowing the dirty oil to run away, this necessitating pumping out in the Rabbeth. In all essential features the Rabbeth may be taken as the best type of self-contained spindle, in which the spindle proper is sustained by rigid bearings, and one of its chief merits is that it can be readily adjusted so as to be quite true with the ring. As a matter of fact this was practically the only advance noticeable in the Rabbeth over its predecessors, and was not perceived even by its inventor until after spindles made under his first patent had been working some time.

(373) During the past few years, however, a new type has been introduced, of which there are now several examples, and which is rapidly superseding all others. Everyone is aware of the tendency of a rapidly revolving body, such as a humming top a little out of balance, to assume such a position that its axis is out of the perpendicular while its revolution is going on with absolute steadiness. The high rate of speed which is attained with ring spindles, running up to 11,000 revolutions per minute, produced as might be expected, a certain amount of vibration which it is desirable to avoid. Consequently, a spindle was produced in America to which the designation of the "top" or "elastic" spindle was given, and which was, while held in a long bearing at the top of the bolster, free to move at its foot until it found its position of steadiness. It was found, however, that the changes of position when the balance was disturbed were so abrupt that it was necessary to restrain the movement to a certain extent.

(374) In Fig. 192 a spindle known as the "Whitin Gravity" is illustrated, being made in this country by Mr. Wm. Ryder, of Bolton. The spindle B has fitted on to it the sleeve A, made shorter than usual. On A the warve is formed, as well as a conical shoulder on which the lower end of the bobbin fits tightly. The bolster C has the usual screwed shank, and passes upward into the sleeve. A noticeable feature of the Whitin is the employment of a loose sleeve in which the spindle fits, and which has an external diameter at the point D about $\frac{1}{500}$ inch less than the internal diameter of the bolster at that point. The lower part of the sleeve is recessed so as to pass over a nipple G formed in the bolster, the size of the sleeve being such as to allow of its adjustment in any direction. On the top of the nipple G a small pad of cork F is placed, the object of which is to limit by its friction the movement of the sleeve and spindle, and also to absorb vibration. The bolster is recessed so as to form a cavity surrounding the tube D, in which the oil is placed, finding its way to the spindle by means of small holes bored in D. The spindle does not, therefore, as in the Rabbeth, revolve in oil, and any sediment which may be in the latter is allowed to settle in a cavity or recess at the foot H. The Whitin can be run without any difficulty at very high speeds. Another spindle in which this principle is used has been largely adopted, and is known as the "Ferguslie." The inner sleeve in this case has freedom of oscillation, which is controlled by a barrel-shaped spring placed



Spindle rail

FIG. 188.

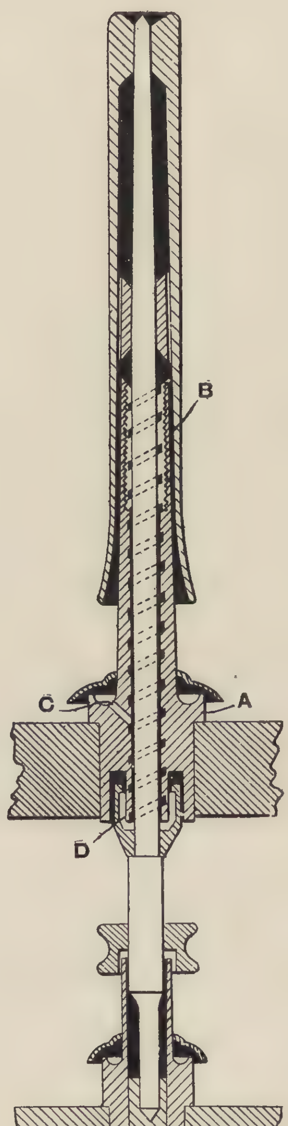


FIG. 190.

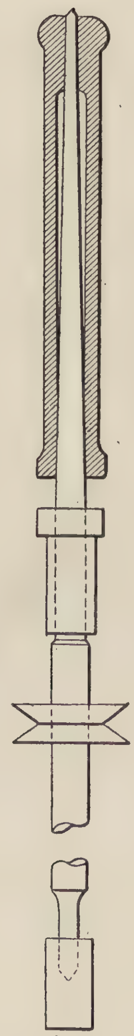


FIG. 189.

round the upper part of the bearing. It may be noted that the lower end of the inner sleeve is quite free, and that the entire control comes from the spring at the top. There are many other forms of this type of spindle, Messrs. Dobson and Barlow, for instance, employing a cork cushion in lieu of a spring. Mr. John

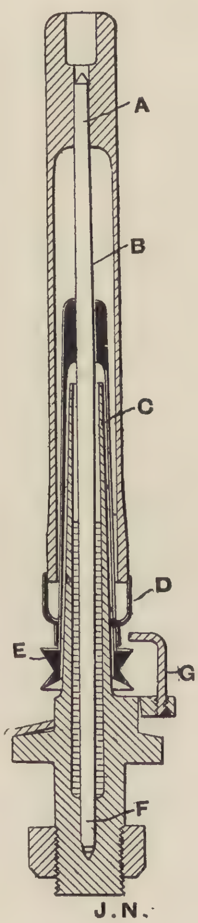


Fig. 191.

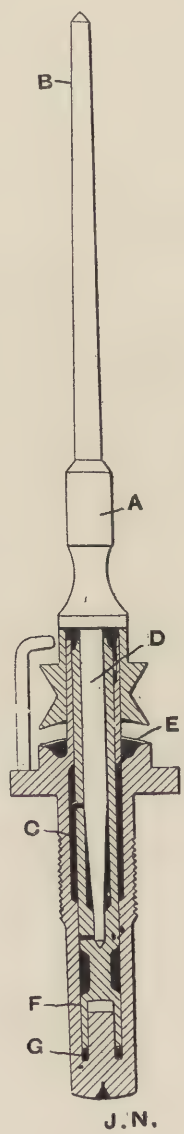


Fig. 192.

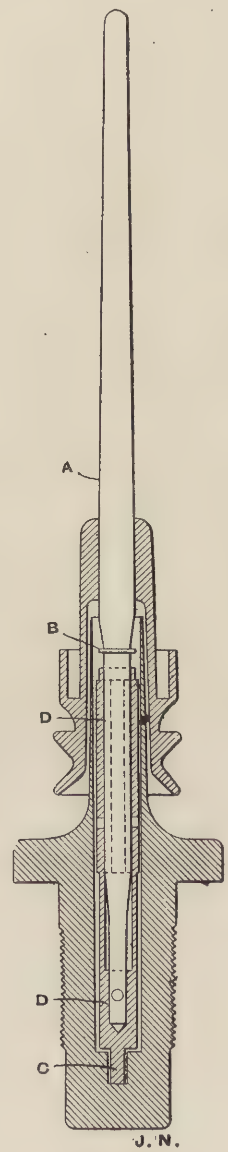


Fig. 193.

Dodd, of Messrs. Platt Brothers and Co., Limited, has patented the spindle illustrated in Fig. 193, which the author is informed is running at a very high velocity, and giving very good results. The spindle A is carried in a tube or bolster D, formed with a rectangular nipple C at its lower end, in order to prevent its turning with the rotation of the former. The spindle A is formed, as shown, of a special shape, being

strengthened above the top of the bolster, so as to be stiffened somewhat where the bobbin fits. The main arrangement of the bolster case, sleeve, etc., is similar to the Rabbeth, but the bolster case extends upwards a little above the bolster, and on the spindle a collar B is formed, by which the oil which works up above the top of D is thrown off so as to catch on the bolster case and run down again into the chamber which is formed at its lower end. The oil passes through holes in the tube, thus providing for an efficient lubrication, and the tube is so fitted into the case as to be a little less than its internal diameter. It is probable that in working D will be constantly surrounded with oil, which will form a pretty effective cushion. At any rate it is found that high velocities can be attained with this spindle, combined with complete steadiness. In Fig. 194 (see p. 249), the "Bee" spindle, which is the invention of the late Mr. George Bernhardt, of Radcliffe, is illustrated. This gentleman gave a good deal of attention to this special class of spinning machines, and was the inventor of many useful appliances in connection therewith. The chief feature of the Bee spindle is the formation of the bearing in the shape of a long tube, which can be withdrawn from the bolster case and emptied of oil without disturbing the spindle. The tube is held in position by a bayonet catch, and can be withdrawn and replaced in a very short space of time. If desired, the tube can be arranged to rotate as it is acted on by the revolving spindle, but this is not essential. The use of a withdrawable tube is a very valuable feature in principle, and is worth favourable consideration. In passing it may be stated that the adoption of spindles with elastic bearings has led to a shortening of the driving sleeve, and a reduction of the height of the top bearing, as a comparison of Figs. 191 and 192 will show.

(375) The ring, the use of which gives its name to the system, is made of the form shown in the drawings, and varies in diameter from 1 inch to 5 or 6 inches, as required, 2 inches being a very common size. The diameter is, of course, determined by the counts being spun, the cop or spool produced being larger in proportion to the coarseness of the counts. A table of the ordinary sizes employed will be found at the end of this chapter. The important points in a ring are its perfect circularity, smoothness of surface, and hardness, three features which tax the energies of manufacturers to obtain at the prices paid for these articles, Formerly rings were produced out of iron of good quality, which was formed into a hoop and perfectly welded, but latterly steel has come largely into use, and it is the practice to obtain the blank without a joint. The rings are in some cases milled, and in others turned and bored to the required section, and are subsequently case-hardened. A large percentage of the soft rings fail in the case-hardening, and the production of a perfect article is only possible with a proportion of the blanks dealt with. In the great majority of cases the ring is made single—that is, with one bead only (Fig. 195)—but Messrs. Thomas Coulthard and Co., of Preston, produce a double ring, shown in Fig. 196, which can be reversed when needed. This firm provide a special holder for their ring, which is fitted on to the rail, and is also formed with a vertical arm or projection which knocks the fly off the traveller as the latter revolves. The fly is—as explained—the collection of loose fibres which are thrown off from the surface of the yarn in its passage to the spindle, and which if left adhering to the ring or traveller increases the drag and causes breakage. It may be repeated here that cleanliness is a most important feature, and requires constant attainment if spinning is to be conducted successfully. A special lubricant is provided for the ring and traveller, ordinary oils being useless.

(376) The travellers are, as previously mentioned, made of a C shape, but this is not invariable, and are of various weights to suit varying circumstances. There are two standards of weight used in manufacturing travellers in this country, one known as the Scotch and the other as the United States. The Scotch standard probably derived its name from the fact that it was originally, and still is, manufactured in Paisley, by Messrs. Eadie Brothers. The difference between the two lies in the size of the bow for fine numbers from 1/0 to 30/— used in spinning 28's counts yarn and finer. The smaller bow is used in the Scotch standard, and it enables a thicker steel to be used, giving greater strength to the traveller and preventing it being pulled off the ring so easily. Thus, in spinning 32's, a number 2/0 to 3/0 Scotch standard can be used, whereas the number in United States standard would be 3/0 to 4/0. For fine yarns a light traveller is necessary, while for coarse counts or strong doubled yarn a proportionately heavier one is used. A good deal depends, however, on the quality of cotton used, good Sea Island, for instance, enabling yarn to be spun with a traveller three or four sizes heavier than that permissible with inferior cotton. The diameter of the ring used, the

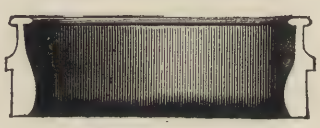


Fig. 195.

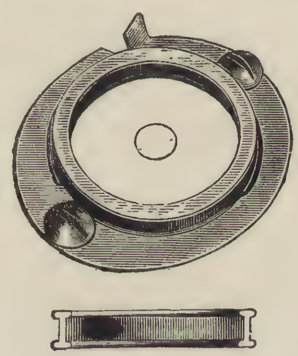


Fig. 196.

number of twists per inch, and the speed of the spindles are among the things which influence the choice of the traveller used. It may be said that, although definite rules are made as to the weight of traveller used for certain counts under fixed conditions, a careful overlooker can make a vast difference in the production by selecting the exact size of traveller best adapted to particular yarns.

(377) Having thus described the essential portions of a ring spinning machine, some of the difficulties and principles of the mechanism may be dealt with. It is quite certain that the full theoretical reasons for the successful accomplishment of this work are not now forthcoming, but an approximation to them is possible. The actual spinning process is merely a twisting together of the fibres of any material by the rapid revolution of a flyer or spindle while the fibre is being delivered at a definite rate. In this case the twist is put in by the rotation of the traveller, which, as shown, is actuated from the spindle. As it has never yet been accomplished to take off the yarn from the spindle at the same rate as it is being wound on, it is necessary that the twisted fibre should be collected on the spindle or on a bobbin super-imposed on it. In order to do this, as was shown in Chapter X., it is essential that the eye or guide through which it is delivered to the

spindle should travel either faster or slower than any fixed imaginary point on the spindle. The latter is the invariable rule with the ring frame, and it will be seen that as the bobbin is revolving at a quicker rate than the flyer eye, or in this case the traveller, it will take up the yarn and gradually wind it on to itself. Of course, in the case of a mule this does not happen, the winding arrangement being there altogether different. The amount of "lead" which the bobbin has should correspond approximately to the number of inches of yarn delivered by the rollers. That is to say, if the yarn is receiving ten twists to the inch, the bobbin should take up approximately, during ten revolutions, one inch of yarn. Now it is quite clear that if the velocity of the bobbin varies, the speed at which the traveller is pulled round the ring will vary also, but that, owing to the resistance caused by its weight and frictional contact with the ring, it will always tend to lag behind the bobbin. A little examination will show that the weight of the traveller is really the determining, or, at any rate, the most important, element in the case. As has been explained, the rotation of the traveller is caused by the pull exercised on it by the yarn. Now the velocity at which ring spindles are revolved is very great, averaging in ordinary cases at least 8,000 per minute. It is quite clear that a traveller rotating at that speed will tend by centrifugal force to fly outwards, and thus cause its inner lip or edge to press against the inside of the ring. Although it is quite true that this contact is only a slight one it exists, and constitutes one of the elements in the case. But it is also evident that the greater the weight of the traveller the greater will be the force that is exerted against the inside of the ring. While the author does not wish to do more than express his own opinion in this matter, there seems to be substantial ground for belief that the tangential pull on the yarn between the traveller and the point at which it reaches the bobbin will to a great extent counterbalance the tendency to fly outwards. It therefore seems probable that the reasonable explanation of the drag of the traveller is to be found in the resistance set up by its weight rather than by its frictional contact with the ring. This is the principle upon which travellers are made, their weight being carefully graded in order to suit various counts of yarn and velocities of spindles. There is another feature in which the weight of the traveller is evidently of importance, and that is its relation to what is known as ballooning.

(378) A glance at Fig. 188 will show that between the ring rail and the nip of the front rollers there is about ten inches of yarn, which, when it is being twisted, is held by the traveller and the rollers, and tends to fly outwards and assume a curved course, which from its shape is called a "balloon." This is caused by the centrifugal action of the yarn and the resistance of the atmosphere, and leads, unless checked, to a serious loss of twist. In addition to this as the distance between the centres of the spindles is only 2 or 3 inches ordinarily, it is obvious that if this tendency is unchecked contiguous ends will come into contact and frequent breakages occur. The author was informed by Mr. Bernhardt that a careful trial made by him established the fact that, where the balloon is unchecked and allowed to attain its greatest size, the breakages are six and a half times as numerous as when its size is in some way limited. There are two methods of doing this, one by surrounding the spindle with a guard which prevents the balloon attaining more than a certain fixed maximum diameter, and the other by so adjusting the position of the thread board that the distance between the wire eye and the

traveller is such that not more than a certain sized balloon can be formed. It is a well known fact that a balloon is absolutely essential to good spinning, as its centrifugal action enables a lighter traveller to be used, and the drag upon the yarn is thus reduced to a minimum. The use of a heavy traveller undoubtedly will check ballooning, but the yarn will suffer, and therefore a well formed but not excessive balloon is of advantage. Mr. Brooks employs a plate (L, Fig. 188) pierced with a number of holes and mounted on pokers, which gradually rise higher as the bobbin fills, so that the balloon is checked by the hole in the plate. Other makers, such as Messrs. Platt Brothers and Co., Howard and Bullough, and Dobson and Barlow, employ forked wire guards which serve the same purpose as the plates referred to. Fig. 194 represents the appliance used by Mr. Bernhardt, which is very effective and is worth attention. Instead

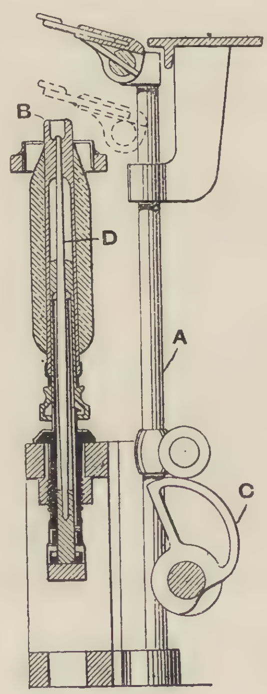


Fig. 194.

of depending upon a guard of the character referred to, the ballooning is checked by maintaining a defined distance between the guide eyes and the ring rail. It is clear that as the latter rises, if the guides are stationary, there will be a greater tendency to balloon when the rail is at its lowest position than when at its highest. More than that, the attainment of the full diameter of the cop is followed by more ballooning than when the building is just beginning, and it is therefore advisable to slightly shorten the distance between the guide and the point of the spindle. The guides are in this case mounted on a rod borne by and attached to vertical pokers A. The vertical position of A is determined by the cam C, which is slowly rotated as building proceeds. The shape of C is such that when spinning begins, the guide eye A is about an inch above the nose of the bobbin, but gradually falls until within ⅝ inch of

the same point, after which it slowly rises until the relative positions at the commencement and finish are as indicated by the dotted and full lines. The rise begins as soon as the cop is formed of full diameter, and one important feature in this invention is that the vertical reciprocations of the guide eyes are independent of, less than, although simultaneous with, those of the ring rail. It is certainly remarkable how effective this contrivance is in checking ballooning, and this without submitting the yarn to any injurious rubbing action. The size of the balloon is accurately checked, while at the same time it is as large as can be permitted under the existing conditions. The inventor stated that the effect of this arrangement is that a bobbin of 6 inch lift can be employed, where in other cases not more than a 5 inch bobbin could be used. The extra length of yarn so wound on is of great service in subsequent processes, giving rise to other advantages which are well known.

(379) So far the mechanism employed has been designed to spin on bobbins placed on the spindles, but there is another branch of the subject to which reference must be made. Although the attempt to spin on bare spindles was made so far back as 1847, this special method of spinning is not even yet completely successful, though it is quite true that many efforts have been made which have attained partial success. It may perhaps help to the understanding of the difficulties of the case to remember that weft yarn is most urgently needed in the form of cops. Now, yarn which is used for weft has many less twists per inch put into it than warp yarn, and is in consequence much softer and more tender than the latter, breaking with less strain, and being altogether more difficult to spin. It is, therefore, under conditions which are the most unfavourable possible that the attempt to spin on the bare spindle in ring frames has to be made. In forming a cop, the diameter on which the yarn is wound is constantly changing, and the largest diameter is only a little smaller than the internal diameter of the ring, while the smallest will be about $\frac{3}{16}$ of an inch. Now, it will be easily understood that the drag exercised by the yarn on the traveller will be greater when it is being wound on the larger diameter than when on the smaller, it being remembered that the spindle is always revolving at a regular rate, and consequently taking up more yarn per revolution on the body of the cop than on the spindle. Thus, if a regular rate of traverse of the ring rail were adopted it is clear that at one point the yarn would be taken up too rapidly, or too slowly at another. In the mule this difficulty is overcome by increasing the speed of the spindles when the yarn is being wound on the nose. It is not possible to adopt any such method in the case of ring spinning, and the solution has been attempted by the adoption of a mode of giving a very quick traverse at the beginning of its downward stroke to the ring rail, so that less yarn is wound on at that point. Of course this difficulty more or less exists even where spools and bobbins are used, but it is not so acute as when only the spindle is employed. The speed of the traveller varies continually, being greater when the yarn is being wound on the larger diameter and less when on the smaller. There is thus a greater resistance when winding is going on at the nose, and breakages occur more frequently at that point. In addition to this there is the difference existing in the way the pull is exerted on the traveller at both points, which will be readily understood by a reference to Fig. 197. It will be seen that the direction of the draught of the yarn is in the first case from

B to C, and is an angular or tangential one, whereas in the second case the pull is from A to C, and is almost radial. As the yarn in proceeding from the rollers to the bobbin is passed through the traveller, it will be clear that while the revolution of the spindle will in the first case draw the traveller round the ring in the direction of the arrow, in the second case it will exercise no tractive power, or at any rate very little, on the traveller, tending rather to pull it against the ring. As the point A is, however, constantly changing its position, a certain drag is given to the traveller, but it is a periodical one, for as soon as its position is altered the old conditions are again established. In this way the yarn is in a sense twitched or wrenched, and breakages occur in consequence. In addition to this difficulty there is another, arising from the different speeds at which the traveller runs, to which reference has been made. Owing to this difference more twist is put in when winding is going on at the largest diameter, and less when at the nose of the

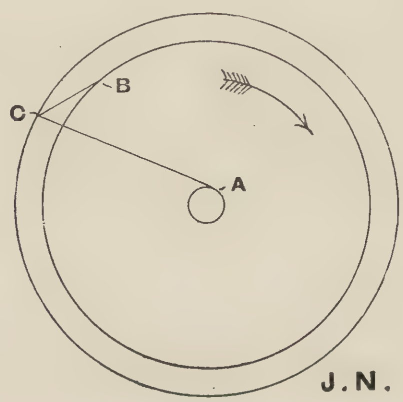


Fig. 197.

cop. Now, the latter place is where it is most wanted, owing to the increased drag, and as weft yarn is always more softly spun a decrease in the number of turns per inch is a fruitful source of breakage. The difference amounts to between one and two per cent, and constitutes really the chief difficulty to be overcome.

(380) As this subject is one of some interest a few words may be profitably expended on it. There is some confusion existing as to the way in which the loss in twist should be arrived at. On the one hand it is contended that the number of coils made in one lift of the ring rail should be counted, and the loss of twist calculated from that. On the other hand, it is urged that the coils laid in a double lift of the rail should be taken as a basis. This is the view held by Mr. Charles Lancaster, of Manchester, who has given a good deal of attention to the subject, and with whom the author is inclined to agree. To arrive at a conclusion it is necessary to ascertain the smallest and largest diameter of the surface of the bobbin, calculating therefrom their respective circumferences. The mean of the latter will give the average length of yarn wound per revolution, and the difference of the two the relative loss in twist. Mr. Lancaster put this matter very clearly, and the demonstration may be given in his own words: "To prove this calculation measure the length of a 'draw'—*i.e.*, the yarn deposited in one up or one down motion of the ring rail—

and multiply by the number of turns per inch, count the number of coils in this layer of yarn (which represents the actual loss), and divide into total number of turns. Thus, if the up motion of the ring rail deposits 72 inches of 20's yarn with 16·75 calculated turns per inch, then 72 × 16·75 = 1,206 ÷ 20 coils = 1·8 per cent of loss; and if the down motion deposits 178 inches of yarn with 16·75 calculated turns, then 178 × 16·75 = 2,981·5 ÷ 46 coils = 1·6 per cent, or an average of one up and one down motion of the ring rail of 1·7 per cent." * Of course the finer the yarn spun the less the percentage of loss of twist.

(381) Whatever be the mode of calculation adopted, whether only the single or double lift be taken into account, the fact remains that there is a loss of twist, and that this is of most account when weft yarns are being spun. It being most desirable to spin these upon the bare spindle, so that they may be used in the shuttles, it will be seen that the subject is one of some importance. Various methods have been tried to overcome the difficulty, one mode being to take the yarn away from the nose of the cop as quickly as possible, but it has only been partially successful. Another, and more successful plan, is to form a special traveller, so arranged that the yarn in passing to the bobbin does not give a radial but a tangential pull to the traveller. The final form of traveller adopted by Mr. William Lancaster, who has tried a large number of shapes for this purpose, is arranged in this way, and to a certain extent frames made by him have been successfully used. The mode of construction adopted by Mr. Lancaster is shown in Figs. 198 and 199. In these the traveller is made at one end with an open fork, and at the other is C shaped, fitting the ring as shown in Fig. 199. Referring to that figure it will be seen that the yarn is carried through the C shaped eye, and then round the foot of the open fork B to the spindle A. The result is that the point where the traveller rests on the spindle acts as a fulcrum, and the yarn exercises a pull on the end of the arm carrying the C, this portion of the traveller practically becoming a lever. In this way the direct radial pull upon the yarn is avoided, and the traveller is readily drawn round the ring. Its actual position on the cop is shown in Fig. 198, where B is the fork, A the yarn, and C the spindle. In this form a number of frames are working with considerable success.

(382) In Figs. 200 and 201 a special form of ring and traveller applied to a bare spindle is illustrated, these being made by Messrs. Platt Brothers and Co., Limited. The ring B has a groove A formed in it, in which a traveller D made of the shape shown is placed. The traveller has a loop or hook E near one extremity, and a second loop C nearer the centre. The yarn is first passed under the loop E, and then through C, thus giving a drag to the traveller at the point E, and causing it to travel round the groove. The loop C lies close up to the spindle when the yarn is at the nose of the cop, so that the yarn passes at once on to the former. The machine so constructed has been in use for some time, and it is found possible to stop it with the ring rail opposite the extreme point of the cop and re-start it without any considerable breakage of ends. In considering this portion of the subject past experience will form a base on which to found future efforts. A combination of a rapid traverse of the ring rail with some means of avoiding the direct pull of the yarn might be effective, but the subject is one for experimental work and not theorising.

* *Textile Manufacturer*, Manchester, March 15th, 1890.

The latter is more likely to retard than aid in the solution of the problem. A differential speed of the spindles has been proposed, but no data exist by which a correct judgment can be formed. If by simple means an approximation to an equal twist can be obtained a great step towards the solution of this extremely

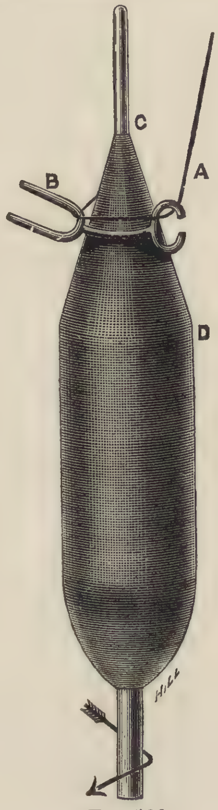


Fig. 198.

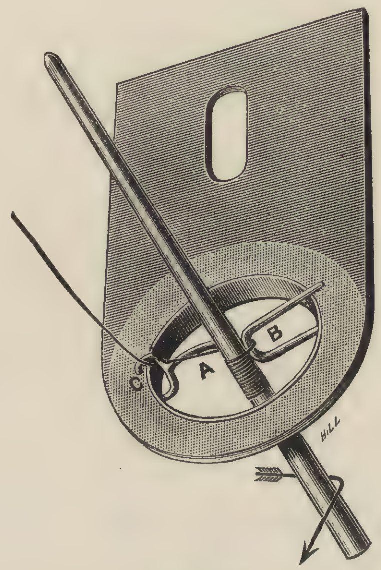


Fig. 199.

difficult problem will have been made. The whole question is environed with difficulty and requires constant attention to a number of little points, but the advance made during the past few years is so remarkable that a good deal of hope can be entertained as to eventual success. In the meantime weft is being spun

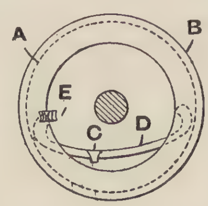


Fig. 200.

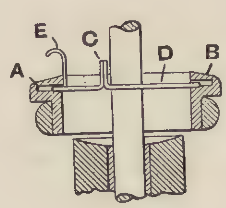


Fig. 201.

successfully on small wooden pirns which possess the great advantage of allowing the whole of the yarn to be unwound from them, and thus save the waste often made by "stabbed" cops. A frame for this purpose, made by Messrs. Howard and Bullough, is shown in Fig. 202, and about 400 grains of No. 20's yarn can be wound on each.

(383) With reference to the details of the machine it has latterly become the practice to drive both tin drums positively, so that there is no variation in the twist of the yarn on different sides of the machine. Such an arrangement—made by Messrs. Asa Lees and Co., Limited—is shown in Fig. 203, the course of the ropes being clearly indicated by the figures attached. The lift of the spindles varies from 5 to 6 inches, and their gauge from $2\frac{1}{2}$ to $2\frac{3}{4}$ inches. The diameter of the front roller is usually 1 inch.

(384) Akin to the ring spinning machine is that employed for doubling. It is, however, heavier in construction, and has a different arrangement of rollers. The rings used are as large as three inches in

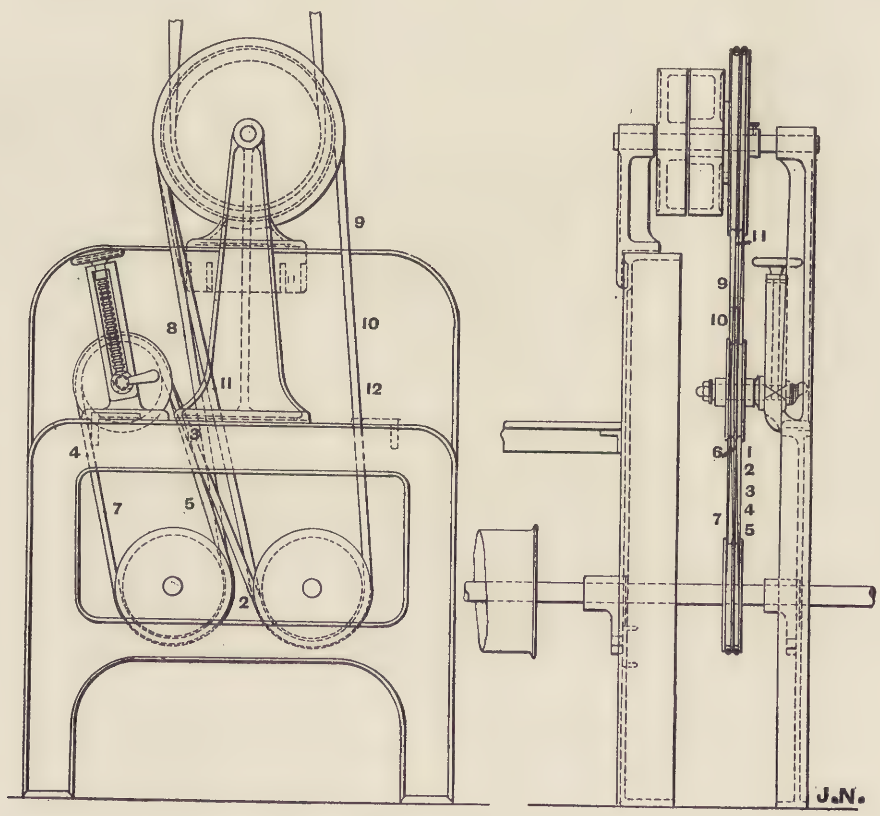


FIG. 203.

diameter, and the spindles have a lift of six inches. The travellers are of a different shape, being made to engage with both the top and bottom flange, or bead of the ring. There are two systems of doubling pursued. In the English system the delivery rollers are placed in front of longitudinal water troughs, so that the yarn may be either passed through the water or not as preferred. In the Scotch system the rollers are placed above the water troughs, and the bottom rollers can, by means of a special arrangements, be lowered into the water. In both cases there are but one line of rollers usually, and, in the case of Scotch doublers these are invariably brass covered. The rollers are much heavier than those used in spinning, as the delivery

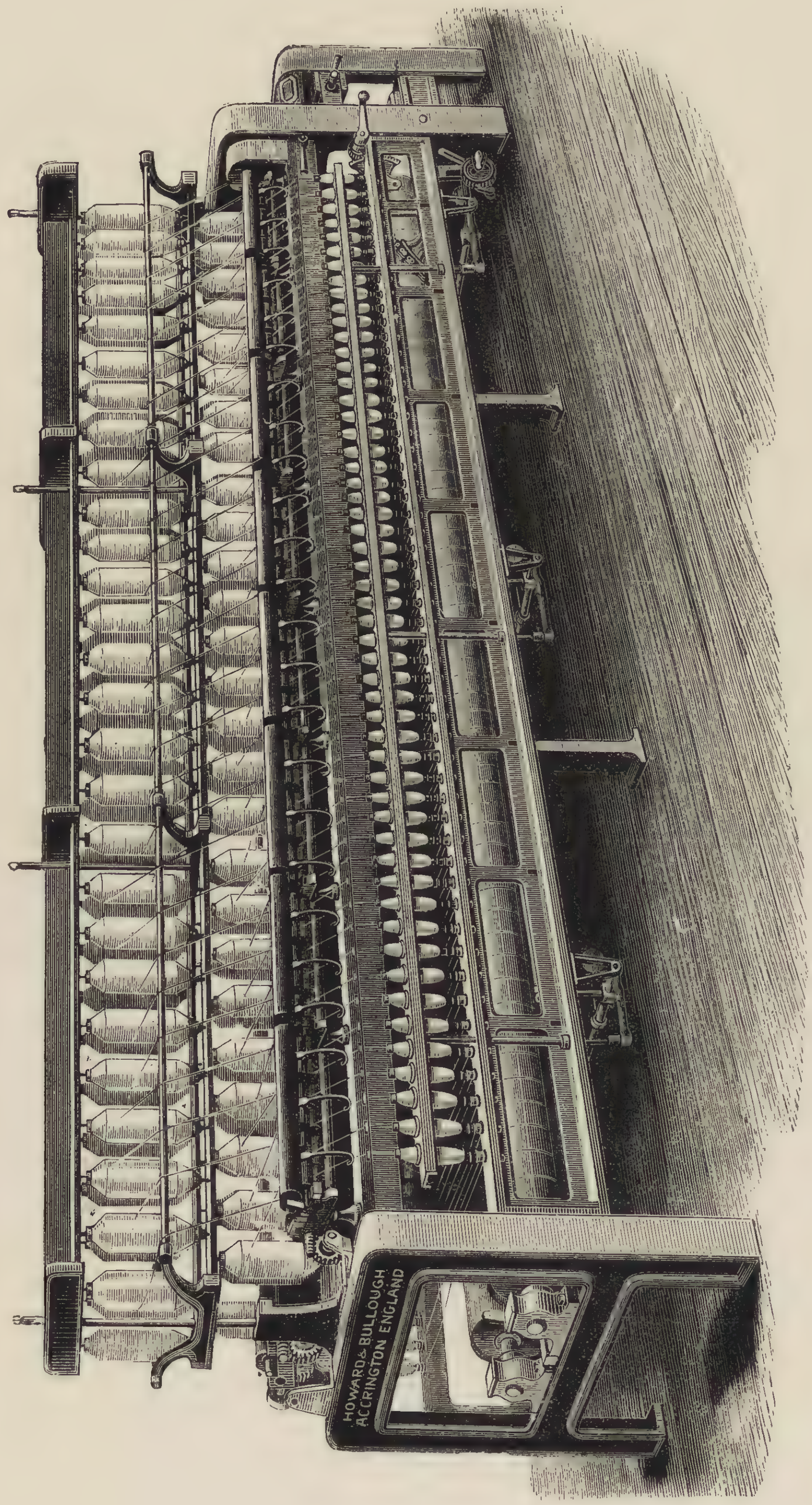


Fig. 202.

of the yarn is accomplished by the nip of the top and bottom rollers, the former not being weighted in any way. In the Scotch frames the rollers are carried by short arms securely keyed on a longitudinal shaft, which, by means of a worm and worm quadrant, can be oscillated so as to lower or raise the rollers into the water trough. In the English system of wet doubling, the yarn is taken underneath a glass rod immersed in the water in the trough, and then through the rollers. It is not necessary to deal further with the details of this machine, as it is practically similar to the spinning machine.

(385) There is a large trade done in "double" yarns—that is, yarns composed of two threads twisted together—these being used for the warps of some of the stronger calicoes, and in the finer grades for many other purposes, such as the manufacture of lace. There is no difficulty in producing these, but the manufacture of sewing thread involves a more elaborate treatment. In carrying this out the yarn is first wound on a machine provided with detector mechanism, and known as a doubling winding machine—this being described in the next chapter. The object of this machine is to enable a two-fold yarn to be produced free from knots of large size, from single, and from slack places in any of the strands, this producing "corkscrews." The latter is the phrase used, when one end of the yarn being twisted has been more slackly wound than the other, thus becoming bagged, and resulting in it being twisted round the other irregularly. These are very objectionable, and not permissible in producing sewing thread, as they cause thick places which catch in the eye of the needle. Having obtained the two-fold yarn, the next operation is that of "cabling"—that is, the twisting together of three of the double yarns. These are, therefore, again wound on to a bobbin or spool on a similar machine to that previously used, and are then twisted together into a six-fold or "six-ply" thread. The advantages of doubling winding will be more fully explained when the machine is described.

(386) In order to enable some idea of the class and weight of the travellers used, the relative speeds of front roller and spindles, and production, a table is appended to this chapter in which a few representative counts are selected. Other tables give the result of a number of tests made with the Emerson Power Scale and other instruments, which enable the amount of driving power required to be ascertained.

(387) The consideration of the various machines employed in spinning being now concluded, a few words may be said generally about the whole system. Before doing so, however, it may be as well to define the meaning of one or two words which are habitually used to define the relative fineness of the yarn. It will be noticed in the table appended to Chapter X. that the roving was described as such a "hank" roving, while the yarn is said to be of certain "counts." Although apparently contradictory, these terms are not really so, being simply different expressions of the same fact. The standard upon which all definitions of the fineness of yarn are based is the "hank" of 840 yards. A hank is the thread wound into coils of 54 inches circumference until a length of 840 yards is obtained. That forms the basis by which the "counts" of yarn are calculated, and the "counts" are simply the number of such "hanks" in one pound weight. In ascertaining the "hank" of roving a certain length is wrapped into a coil and weighed. The weight is obtained in grains, and that sum is then divided into a constant

number obtained as follows: The number of yards of roving taken is multiplied by 100 and divided by 12. This practically means taking 8·33 as a constant number and multiplying it by the number of yards of roving wound. The same procedure is pursued with the lap and sliver on the scutching, carding, and drawing machines. It is no part of the scheme of the present work, however, to do more than glance at these modes of calculation, as there are many books of rules already in existence, but it may just be stated that the amount of twist which is put into any yarn is determined by the following method: The square root of the count is taken as the basis of the calculation, and is multiplied for mule twist by 3·75, for ring frame or extra hard twist by 4, and for weft yarns by 3·25. The product of these calculations give the twist per inch for any counts of yarn it is desired to spin. The three multipliers thus given are sufficient for ordinary uses, but if yarn is spun for doubling purposes the multiplier is 2·75, and if for hosiery purposes 2·50.

(388) In conducting the manufacture of cotton into yarn, it is desirable to remember that a gradual reduction in its substance is wanted, and all the draughts throughout the whole series should be carefully graded to ensure this. It is extremely undesirable to overstrain the cotton at any point, and this would be the inevitable result, unless the whole of the speeds were designed to give a gradual reduction. This is a factor which it is unwise to neglect, and by a little careful observation, the correct draughts throughout the process can easily be arrived at. It is, however, essential, if it is desired to produce a good yarn, that the mode of obtaining it should be carefully thought out before passing the cotton through the scutchers. Practically, the hank drawing and hank sliver are the same, but the former is obtained from several slivers, so that there is at this stage a considerable reduction. After this point the attenuation should be steadily kept in view, until the completion of spinning. In conclusion, it may again be urged that cleanliness and care in the use of spinning machines will well repay the spinner. It is worth his while to see that the machinery he employs is well made to begin with, and is kept in good order subsequently. By doing so, he will ensure the production of a good yarn, which cannot be spun in profitable quantities, without an undue amount of waste, on machines which are neglected and allowed to fall out of repair.

TABLE 4.

PRODUCTION OF RING SPINNING FRAMES FROM ACTUAL TESTS.

MESSRS. HOWARD AND BULLOUGH'S MACHINES. RABBETH SPINDLES.

Counts of Yarn to be Spun.	Speed of Spindle per Minute.	Speed of Front Roller per Minute.	Diameter of Front Roller	Turns per inch of Twist.	Diameter of Ring.	Number of Traveller. U. S. Standard.	Production per spindle per week of 56½ hours. In Pounds. lbs. ozs.	In Hanks.
10's	6,020	158	1	12·12	1¾	7's or 6's	5 4	52½
16's	6,800	133½	1	16·21	1¾	4's or 3's	2 12	44
20's	7,300	132	1	17·60	1¾	2's or 1's	2 2½	43½
24's	7,500	130	1	18·36	1¾	1/0 or 2/0	1 12¼	42½
28's	7,500	116½	1	20·49	1½	2/0 or 3/0	1 5¾	38
30's	7,500	119	1	20·00	1½	3/0 or 4/0	1 4¾	39
32's	7,500	111½	1	21·41	1½	4/0 or 5/0	1 2½	37
34's	7,500	107	1	22·31	1½	5/0 or 6/0	1 0	34½
36's	7,500	101	1	23·63	1½	6/0 or 7/0	14½	33
38's	7,500	97	1	24·50	1½	7/0 or 8/0	13¼	31½
40's	7,500	94½	1	25·25	1½	8/0 or 9/0	12	30½

NOTE.—With elastic spindles an increase of production occurs of about 20 per cent.

TABLE 5.

POWER TESTS OF RING SPINNING MACHINES MADE AT THE DWIGHT MANUFACTURING CO., CHICOPEE, U.S.A., APRIL, 1885, BY MR. H. S. CHASE.

Date.	Time.	Make of Frame.	Spindle.	No. of Spindles.	Counts.	Condition.	Spindle Speeds.	H.P. required for Frame.	No. of Spindles per H.P.
April 9th	2-0 to 5-30 (3 tests)	Lowell Spinning	Rabbeth	192	28's	Bobbins from ½ full doffed to ½ full again.	7439	1·5915	120·7
„ 10th	10-30 to 11-30	Do.	Do.	192	28's	Bobbins ½ full till full	7324	1·5094	127·2
„ 11th	8-15 to 11-30	Do.	Common 11 oz.	208	21's	Mean of 11 tests, Bobbins empty, running an hour.	6409·5	2·4930	83·4
„ 13th	9-0 to 2-30	Biddeford Spinning	Sawyer	144	21's	Bobbins ⅝ full till doffed and filling again.	7184·5	1·2565	114·9

TABLE 6.

TESTS MADE AT LONSDALE, RHODE ISLAND, U.S.A., BY MR. W. S. SOUTHWORTH, NOW SUPERINTENDENT OF THE MASSACHUSETTS COTTON MILLS.

SAWYER SPINDLES.

REVOLUTIONS PER MINUTE.		POWER FOOT POUNDS PER SECOND PER SPINDLE.			Number of Spindles to One Horse-power.
Front Rollers.	Spindles.	Empty Bobbins.	Full Bobbins.	Mean.	
59·2	5,408	3·140	3·675	3·407	161·4
63·95	5,842	3·536	4·139	3·837	143·3
69·9	6,386	4·025	4·933	4·479	122·8
75·85	6,929	4·659	5·655	5·157	106·7
82·5	7,539	5·338	6·537	5·937	92·6
88·9	8,124	6·034	7·331	6·682	82·3
97·95	8,948	7·009	8·419	7 714	71·3

The weight of the Spindle was 3·98 ozs., of the Full Bobbin 2·23 ozs., and of the Empty Bobbin 71 ozs.

TABLE 7.—EXTRACTED FROM THE JOURNAL OF THE FRANKLIN INSTITUTE.

TEST OF RING SPINNING SPINDLES, MADE AT CALLAGHAN'S MILLS, ANGORA, U.S., BY MR. S. WEBBER, 13TH MARCH, 1890. COUNTS SPUN 30's.

	Bates Spindle.	Whitin Spindle.
Revolutions of front rollers (counted)	100	100
Revolutions of spindles (calculated)	8360	8160
Average power in foot-pounds per spindle	8.11	5.50
Average number of spindles per H.P.	67·4	100
Average H.P. per frame	3·144	2·219

Table 8.—Extracted from the Journal of the Franklin Institute.

TEST MADE BY MR. S. WEBBER, AT THE GLOUCESTER GINGHAM MILLS, GLOUCESTER, NEW JERSEY, U.S., ON THE 17TH MARCH, 1890.

COUNTS SPUN, 26's.

	Bates Spindle.	Excelsior Spindle.
Revolutions of front roller (counted)	102	107
Revolutions of spindles (calculated)	8039	8430
Foot-pounds per spindle (bobbins half full)	7·35	6·89
Spindles per H.P. (do.)	75	80
H.P. per frame (do.)	2·737	2·554
Rollers disconnected H.P. for rollers alone	·462	·491
Do. H.P. for spindles and tin roller	2·264	2·064
Do. H.P. for tin roller only	·462	·462
Do. H.P. for spindles only	1·802	1·70
Spindles per H.P. spindles only	113	120

Note.—Tables 7 and 8 are merely given because they throw considerable light on the question of the power required for ring frames. The Bates spindle is not described, as it is a new form and has not yet been thoroughly tried practically.

CHAPTER XIII.

REELING, WINDING, AND SPOOLING MACHINERY.

(389) There are two main classes of goods in the manufacture of which yarn produced as described is used. By far the greatest bulk is utilised in weaving fabrics of various kinds; and, before it can be so employed it necessarily requires treatment by a series of machines. With all the processes so involved it is not intended to deal, but there is a second class of manufacture—the production of thread—which requires special machines, and is worthy of separate treatment. It is also a very common practice in England to form yarn into hanks, a number of which are packed together, and formed into a "bundle." In this shape large quantities of yarn are shipped, being afterwards employed abroad in the manufacture of cloth. A brief description of the machines used in this connection will therefore be given, and as the simplest mode of dealing with the material, reeling will be treated first.

(390) The yarn, spun either in the form of a cop or on ring bobbins, can be formed into hanks by means of a machine known as a "reel." It depends upon whether it is employed to wind the yarn from cops or bobbins whether it is known as a "cop" or "bobbin" reel. In either case the hank is wound upon a "swift" or "fly," consisting of a central barrel or roller, which has centres or axles formed at each end. The latter revolve in bearings in, or attached to, the framing, and the "fly" can be driven either by hand or by a belt from the line shaft or counter shaft. On the barrel is fitted a number of light wooden or iron frames, to the arms of which are attached longitudinal bars or "staves" of timber. These are made about 2 inches wide, and are rounded on their outer edges, being well polished and smoothed so as not to adhere to the yarn. The arms, as ordinarily constructed, are made double with a central boss, so that each has two "staves" fixed to it. When desired, the whole of the arms can be oscillated so as to bring the staves together, and the hanks wound upon the swift are thus left loosely hanging upon them. By drawing them to one end they can be easily slipped off when that end is raised. The number of hanks usually formed at one time is forty on each swift, and ordinarily one swift only is used in a cop reel and two in a bobbin reel. The appearance of the last named machine is well shown in Fig. 204, which is a representation of a double bobbin reel as made by Mr. Joseph Stubbs.

(391) The general description thus given of the reel enables some of its details to be more particularly described. If cops are to be "reeled" they are placed on "skewers"—which correspond in size to the upper portion of mule spindles—fixed in a creel board. The cops are held at such an angle that the yarn draws easily off the cop nose. The threads are slipped into slits formed in a guide plate fixed to a guide rail sliding in suitable bearings. The same course is taken with the bobbin reel, but, in this case, the bobbins

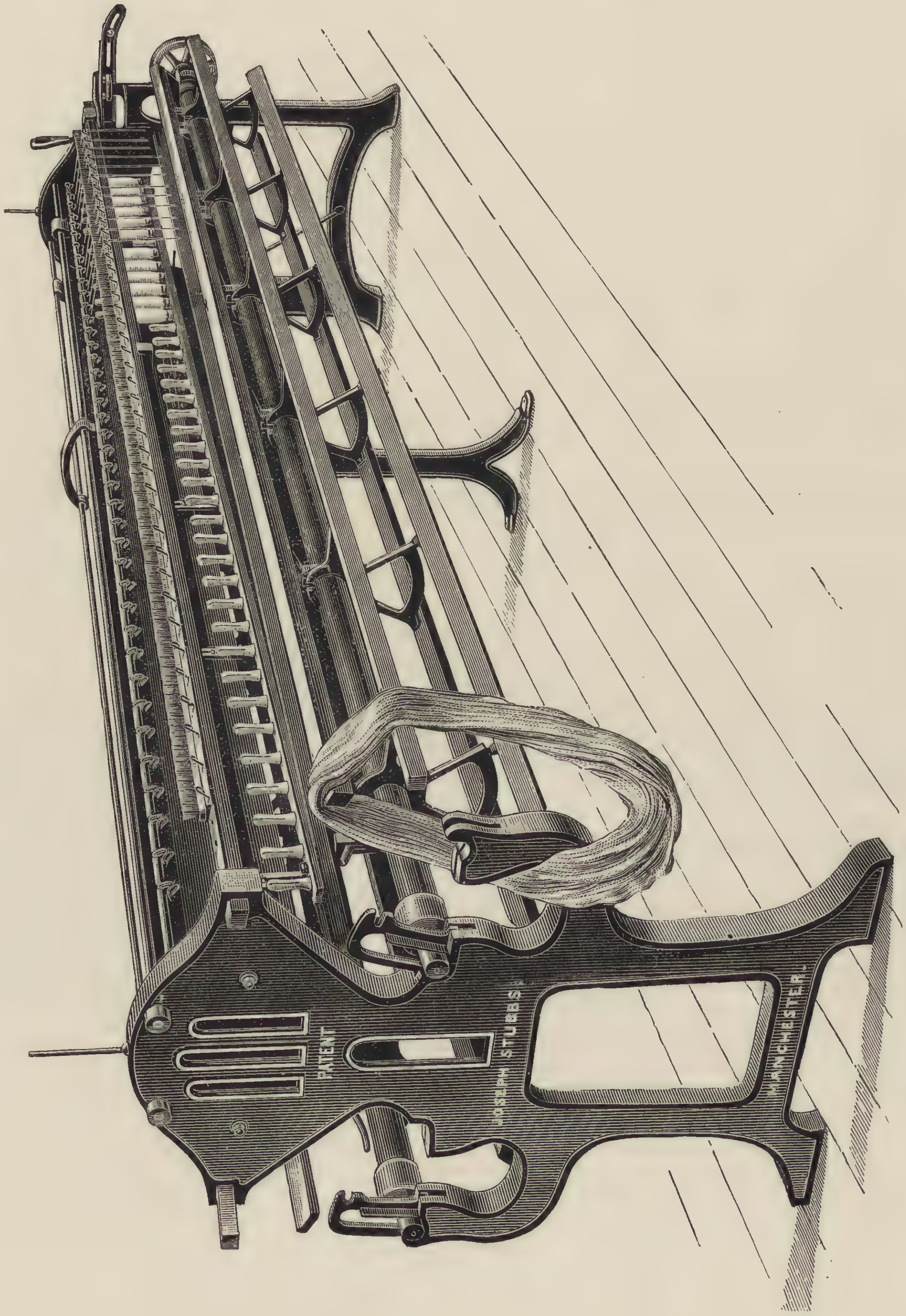


Fig. 204.

are mounted in a somewhat different manner. Ring bobbins require a special arrangement to enable the yarn to be easily drawn off without running into "snarls." The purpose of the guide rail is to traverse the yarn so that the threads may be laid in one of two ways. Either the full hank of 840 yards is wound into seven smaller ones—each containing 120 yards—known as "leas"; or it is "cross wound"—that is, a rapid reciprocal motion is given to the guide rail, so that the coils are laid across each other throughout the whole length. The latter is the usual procedure when it is intended to dye or bleach the yarn, and the former when it is to be shipped. The diameter of the swift across the staves is usually sufficient to enable a hank of 54 inches circumference to be wound. In France a hank of $56\frac{1}{4}$ inches is adopted, and the number of coils in it are correspondingly arranged.

(392) If the hank is intended to be wound in seven "leas" the arrangement shown in Fig. 205 is used. This is a partial side elevation of one end of a bobbin reel. The barrel B of the swift is made of a light wrought iron tube, into each end of which plugs, reduced at end, are welded, so as to form the journals for the barrel as described. On the end of the axle the fast and loose pulleys are placed, so that the machine can be easily driven. The staves A are shown without their connecting arms. On the end of the barrel a worm C is fixed, which gears with the wheel D on the shaft, to which a lifting catch or pawl E is fastened. This engages with the coarsely pitched rack F, and every revolution of the wheel D causes the pawl to raise F one tooth. The teeth F are formed at the lower end of the bracket or "rack" G, which is guided by and slides in the frame. The upper end of G is formed with seven steps, and a finger or pin, placed at H in a bracket fastened to K, is constantly pressed against the face of G by means of a spring exercising a longitudinal pull on K. The raising of G to the extent of one of the teeth F is sufficient to allow the pin H to slip on to the next step, and thus the yarn is wound on to a fresh portion of the surface of the swift. This takes place regularly until seven small hanks are wound, when the machine is automatically stopped.

(393) The length of yarn in each of these "skeins" or "leas" is ordinarily 120 yards, and it is, therefore, necessary to cause the wheel D to make one revolution every time the swift has made 80 revolutions. The length of the hank being $1\frac{1}{2}$ yards—54 inches—that number ensures 120 yards being wound prior to the rack G being lifted one tooth. If it is desired to shorten the hanks, a smaller wheel must be substituted for D, and to get the desired amount of exactitude, it is sometimes necessary to use a series of change wheels.

(394) It was shown that in order to remove the hanks from the reel, it is customary to close up the swift, and, after gathering the hanks at one end, to lift it and thus remove them. There are two chief objections to this course. First, a considerable danger exists of the yarn being soiled by contact with the greasy bearing; and second, the task of lifting a heavy swift with 40 hanks of yarn on it is sometimes too great for the attendant, who is generally a woman. It is customary, therefore, especially in bobbin reeling, to fit the machine with a "doffing motion"—the operation of stripping a spindle or other surface of yarn being known as "doffing." The staves are fixed on the ends of the arms of an iron spider, and two of them are sustained by a hinged frame which can be released so as to oscillate in a forward direction, thus "dropping" the two staves attached to it. This is called

the "drop motion." The hanks are thus released, and can easily be drawn up to the doffing motion. There are three forms of this. The first consists of a wheel, grooved on its periphery and fitting in a circular bracket turned to correspond. The centre boss of the "doffing wheel" bears one end of the swift, and a segment is removed from the wheel, so as to leave a space into which one side of the hanks can be placed. By giving the wheel a half turn the hanks are brought to the front of the swift, and can be easily removed. Another form, which was introduced by Mr. Joseph Stubbs, was called the "gate" doffing motion, owing to the fact that a hinged bracket similar to a gate was used, by removing which the end of the swift was left free. The movement of opening the gate oscillated a lever, on which was a cross bar enabling the swift to be sustained during the operation of doffing. A further improvement by the same firm bears the name of the "bridge" doffing motion, and is shown in Fig. 204. It

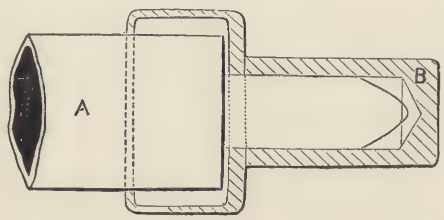


FIG. 206.

simply consists of a small bracket bridging a gap formed in the frame end, in which a longitudinal slot is made, and at each end of it pivots are formed upon which it can be oscillated. The end of the swift barrel A (Fig. 206) is fitted into a round shell B, in which the lubricant is retained, and a nipple on which slides in the slot in the bridge bracket. The doffing is effected by simply allowing the hank to be drawn into the gap named, and then by a smart push making the bridge bracket rest upon its pivots at the other side of the gap. This enables the hanks to be easily lifted, after which a pull is sufficient to restore the swift to its working position. The position of the bridge in its working position and during doffing, is shown on the left and right hand side respectively of Fig. 204. This motion is an undoubted improvement on its predecessors, and oiling of the hanks is practically unknown.

(395) Messrs. Guest and Brooks have recently introduced the skeining motion shown in Fig. 207. In this case the rack G is driven, not by a lifting tooth, but by means of the pinion E gearing with a finely-pitched toothed rack F. In this way a continuous motion is given to G. At the upper end of the latter, a bracket or arm M is formed, having fixed at one end a centre pin O, on which the bracket, or arm, P can be oscillated. The position of P is fixed by means of a bolt and nut passing through it and the slot R. The stepped portion of G, instead of being cast, is obtained by the use of six bars L, which have a certain vertical movement given to them by small pins engaged in the slot Q formed in the arm P. The pins are fastened in the bars, and it is clear that the vertical elevation of the arm P will shorten or lengthen the steps formed by the difference in the length of the bars L. In this way skeins, or leas, of any desired length can be wound, it being obvious that, if the steps be shortened or lengthened, the engagement of the pin K^1 with them

successively, will take place at proportionate intervals, and K^1 being fixed in the bracket K which is attached to the guide rail H, a shorter or longer lea will be formed prior to the traverse of H taking place.

(396) The hanks being reeled, they are, if cross reeled, dyed or bleached, and, if in leas, bundled. This operation is effected in a machine called a "bundling press" (Fig. 208) consisting of two strong frames securely fastened together by stays, and in which the bearings for the necessary driving straps are formed. Bundles

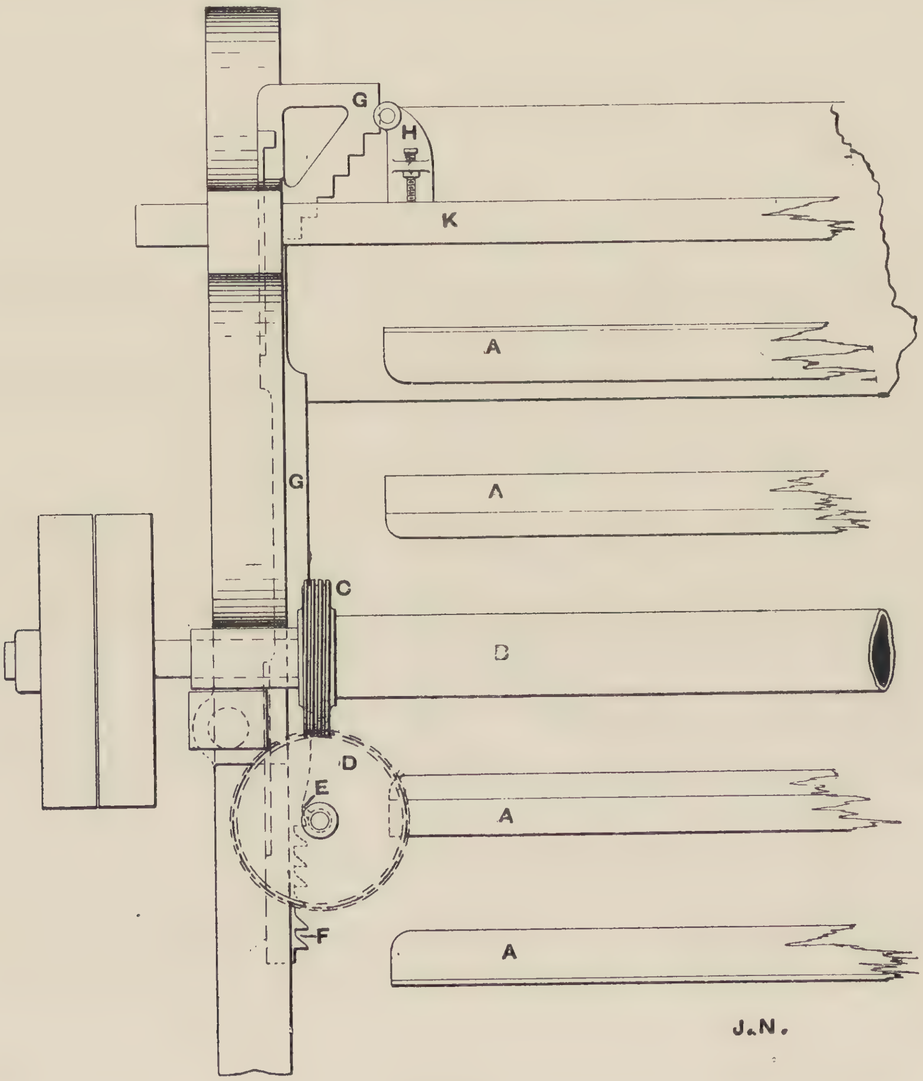


FIG. 205.

are usually either 5lbs. or 10lbs. weight each, and are generally fastened with five strings. To the upper part of each of the frames wrought-iron plates, extending upwards, are fastened, narrow spaces being left between each pair of plates, so that the strings or bands for tying up the bundles can be easily passed round them. To the upper end of one set of plates cover bars are hinged, which can be pulled down on to the top of

the other set, where they are locked by bars hinged to the latter. In the space between the two sets of vertical plates an iron table rises and falls, and it will be readily understood that the elevation of the table, when the top plates are closed and locked, compresses the bundles. The extent to which the pressure is exerted depends on the throw of two eccentrics fixed on the main shaft, these being connected by means of strong rods to the underside of the sliding table. By this arrangement the amount of pressure is strictly limited and cannot become excessive. After the bundle is pressed it is tied up and the pressure released, the top

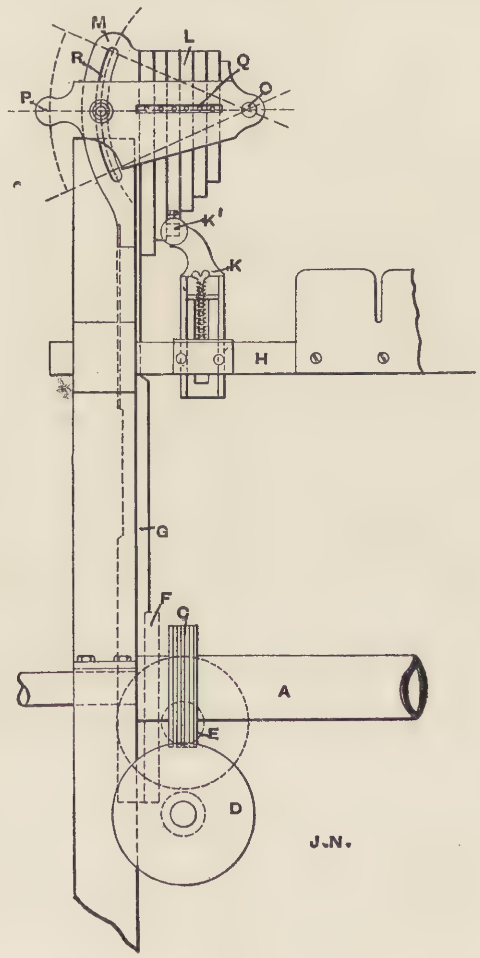


Fig. 207.

bars unlocked, and the bundle removed, in addition to which a knocking off or stop motion is fitted. In an improved form of press, invented by Mr. Thomas Coleby, the top plates are automatically and simultaneously released.

(397) The procedure thus followed is that which is adopted in the case of yarns for export only. Where it is intended to twist them into thread a special machine is employed to wind the several strands together prior to doubling. Machines of this class are called "doubling winding" machines, and they enable a more perfect

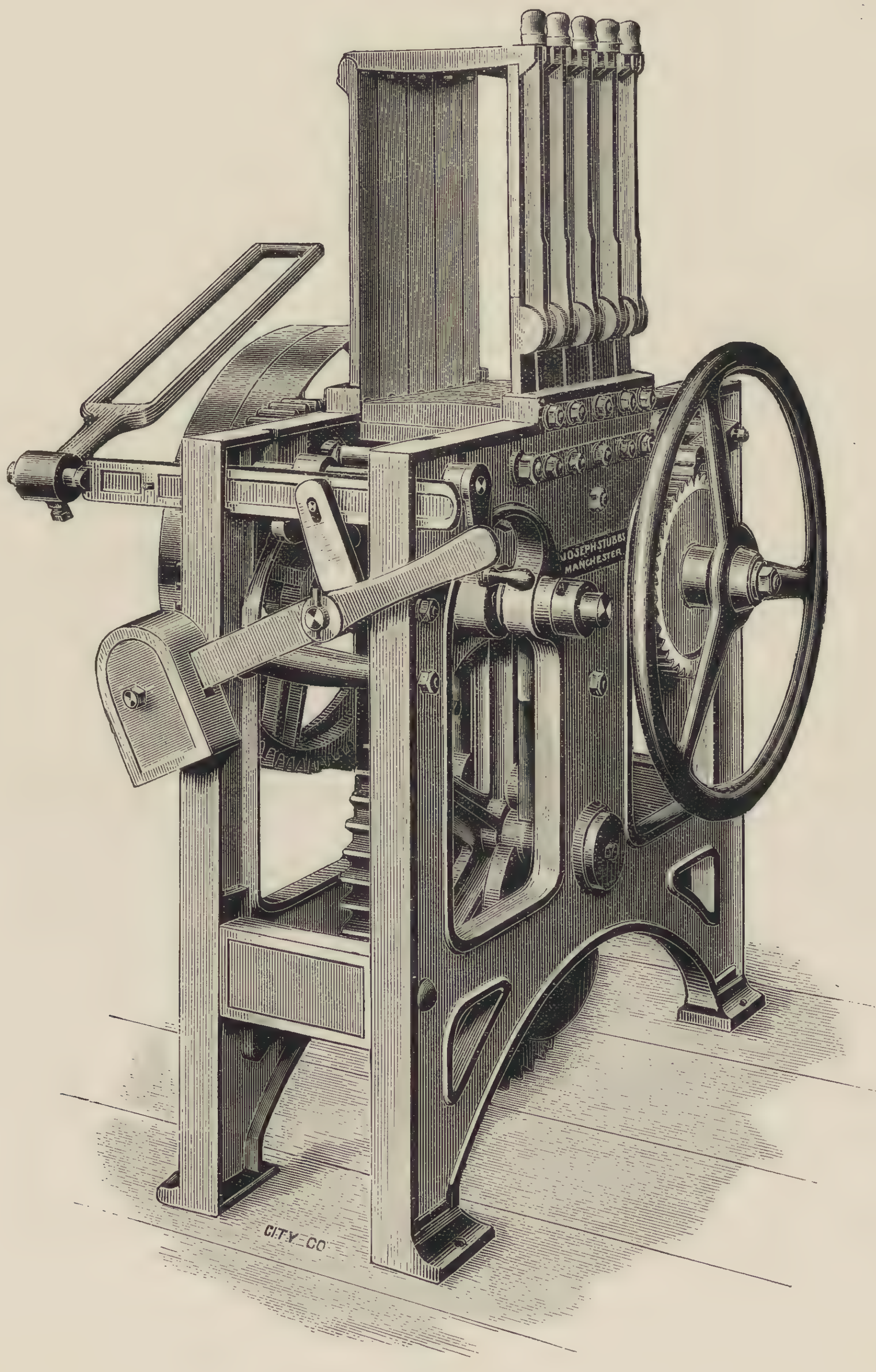


Fig. 208.

thread to be produced than is otherwise possible. When yarn is "doubled" by twisting together threads drawn singly from cops or bobbins placed in a creel, there are two chief evils existing. If one of the threads breaks, a certain length of the single thickness may be wound on the doubling bobbin, with the result that a faulty place in the finished article is found. There is, in addition, the difficulty that the broken thread may become wrapped round the top roller, producing a "roller lap," which is so much waste. The production of "single" and of "roller laps" is undesirable, and should be avoided if possible. Further, if the two threads in passing through the feed rollers are not both at the same tension, one becomes loosely twisted round the other in a manner which is technically known as "corkscrewing," as explained in paragraph 385. When thread is used for sewing machine, lace, or similar purposes, either of these faults is very objectionable. By using a machine in which the strands to be twisted are wound together before being so treated, and in which detector mechanism is employed, a finished thread is produced, which is generally quite free from the defects named.

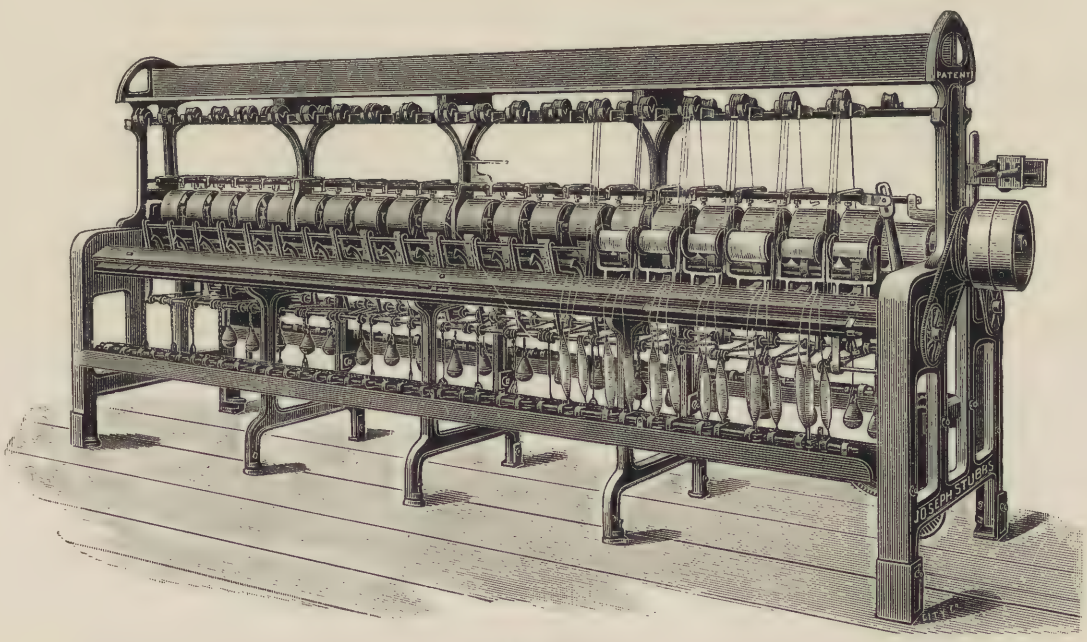


Fig. 209.

(398) In Fig. 209 a perspective view of a doubling winding machine made by Mr. Joseph Stubbs, and in Fig. 210 a transverse section of the same machine, are given. Mounted on a shaft, extending longitudinally of the machine, is a series of drums A, which drive by frictional contact flanged bobbins B. The latter are held in the head of forked cradles C, and revolve freely upon a small spindle. The lower ends of C are subjected to the pull of weights J, connected with them by chains, as shown by the dotted lines. Coupled to the tail of the cradle C is a double frame E, which carries at its outer extremity a swinging or oscillating box or frame, in which are placed a series of small wires—known as detector wires

—corresponding in number to the strands to be wound. The wires are formed at their upper ends G with a curl, and their lower ends F are straight. Immediately below the box a three winged wiper H revolves at a rapid rate. The operation of this mechanism is as follows. The cops to be wound have skewers thrust into them, which fit in adjustable cast iron brackets fixed on a longitudinal rod in the bracket O, fastened to the "bottom box." In the case of bobbins, special provision is made for holding them. In any case, the yarn is drawn upwards through a guide plate fixed as shown, over a flannel-covered curved rail Y, the friction of which is sufficient to ensure a sufficient tension being put upon the yarn. Each "end" is then taken through one of the detector eyes G and upwards over a light roller X, then through a guide wire W, secured to the rod or rail Z. To the latter a reciprocal lateral motion is given, corresponding in length to the length of the bobbin between the flanges—in other words, to its "lift." After passing the guide wire W the yarn is taken to the bobbins B, and as the two bobbins are by reason of their position on each side of the drum A driven in opposite directions, the yarn is taken on to them at different sides of the centre of the bobbin barrel. So long as the "ends" are being wound, the lower end F of the detector wire is kept out of the path of the wiper H, but when, from the failure, breakage, or slack tension of an "end," this sustaining power is withdrawn, the end F of the wire affected comes in the path of H. This causes the oscillating box to swing on its centres, and thus to release the holding down catch I, which usually keeps the pivoted frame E pressed downwards. This release is followed by a certain movement of the cradle C, set up by the pull of the weight J, and brings the bobbin B on to a brake surface D, by which its motion is instantaneously arrested. To piece up, the bobbin can be drawn forward into the position shown on the right hand side of the drawing in dotted lines, so that it can be turned back as much as required. The position of the parts before and after an "end" has failed is clearly shown on each side of the drawing respectively. It only remains to be said that a box T is fixed on the position shown, on which the wound bobbins can be placed prior to removal. Although the yarn is wound at a speed of 4,000 to 5,550 inches per minute, a broken end is usually arrested before it reaches the bobbin.

(399) In preparing thread for the lace trade it is the practice to remove the loose fibres, or "ooze," projecting from its surface. This is done by a machine called a "gassing" frame, a sectional view of one head of which, as made by Mr. Stubbs, is shown in Fig. 211. This represents one side of a machine only. The bobbin B is driven by frictional contact with a drum A, revolving rapidly, and is held in a weighted frame C, hinged at its inner end. C is raised by a bracket or arm D, mounted on the same pin. At the inner end of D is a slot in which a finger fixed on the stem of the burner E engages. The burner derives its gas from a tube G running along the frame, and is fixed in a swivel joint, being generally of the Bunsen type. The thread is drawn from the bobbin K, mounted on a freely revolving spindle, and is passed two or three times, as shown, over the grooved bowls H, these being formed with four grooves for the purpose. A guide I, receiving a longitudinal reciprocatory motion, guides the thread on to the surface of the bobbin B. As the thread passes rapidly through the gas flame from the upper end of the burner E, the "ooze" is rapidly singed off. When an end breaks or is "burnt down" the lever D is raised so as to lift the

frame C and bobbin B out of contact with the drum A, and is sustained by a catch during the time of piecing. The same movement causes the burner E to be pushed at one side out of the path of the thread, and the restoration of the parts to the position shown again brings it gradually under the thread, but not until after the winding has commenced.

(400) In addition to these machines, where lace yarns are made it is sometimes the practice to use a "clearing frame." This is an ordinary vertical spindle winding machine, but the yarn is passed through an adjustable nick, which is finely set, so as to catch or stop any knots or other unevenness in the yarn. This

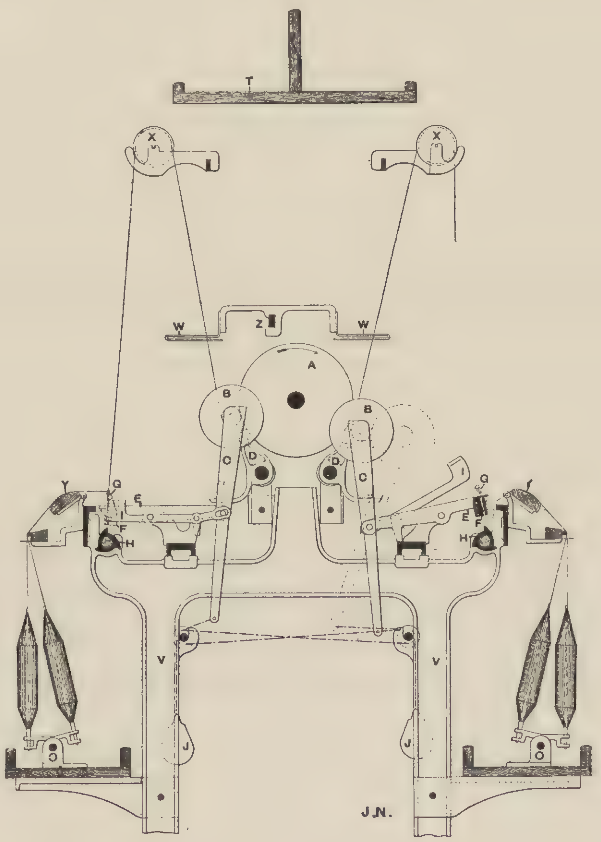


Fig. 210.

calls the attendant's notice to the defect, and the thread is re-pieced, so as to remove the lump or knot. The best and most widely used "clearers" are those known as "Suggitt's" patent, and consist of two cast iron plates, one fixed and the other adjustable. Vertical faces are formed on these, which come up to one another throughout their whole length, thus providing an opening or fine nick through which the yarn can be drawn.

(401) During the past few years it has become customary to dispense with the large flanged bobbins, such as are shown in Figs. 210 and 211, and to wind the yarn into a similar shape on a wooden or paper

tube or spool. To do this it is necessary to give a very rapid reciprocal traverse to the guide rail, which is obtained by using a quick pitched cam, one revolution of which will give the double traverse required. In this way, instead of the yarn being wound in fine spirals, it is wrapped in coarsely pitched layers, and it is found that when wound in this manner a cylindrical spool or bobbin can be obtained which does not require the large wooden flanges to prevent it from unravelling at the ends. This object is attained in a winding machine made by Mr. Samuel Brooks by forming a slot, corresponding to the cam course, on the surface of the pulley driving the bobbin. The yarn is taken through the groove on its way to the bobbin,

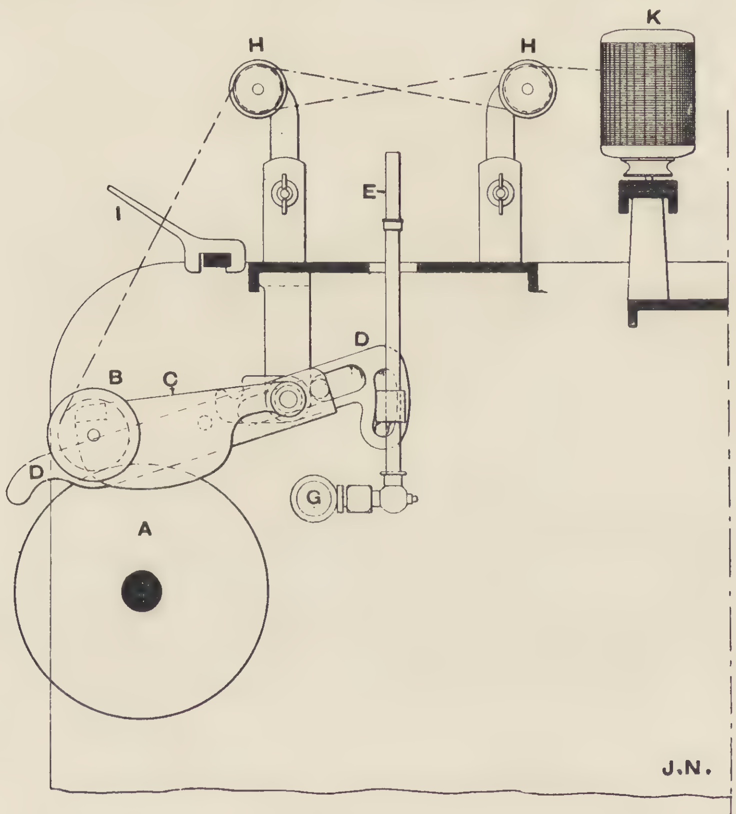


Fig. 211.

and the groove thus acts as a guideway or course. Messrs. Dobson and Barlow employ a quickly pitched cam, and have recently adapted the principle to gassing machines. Messrs. John Hetherington and Sons also make a machine on the same principle, but all the different methods employed have—where a guide rail is actuated—the fault that the working of the cam is rather noisy, and there is still room for an effective noiseless motion of this character.

(402) Sewing thread requires a special set of machines to fit it for the market. It is sold in one of two forms, either bright or soft finished. Bright thread is polished by being subjected to the action of a rapidly revolving brush. Some of the machines for this purpose made by Messrs. Shepherd and

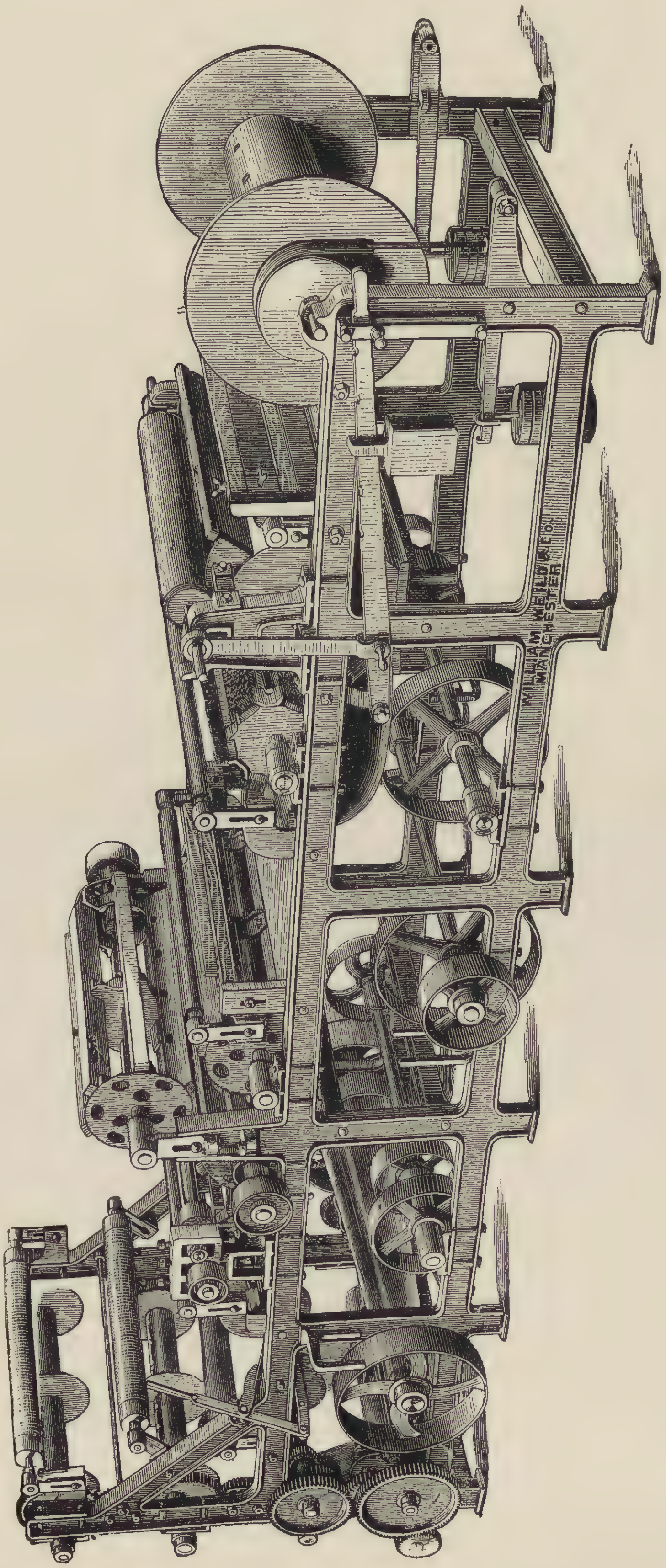


Fig. 213.

Ayrton are illustrated, and will serve to show the principle of this class of appliances. The doubled thread is formed into a beam, having first been wound on to special bobbins, 360 of which are placed in a creel, and the threads from them laid side by side on the beam, which is a cylindrical barrel with large flanges at its ends. The thread is then collected into a chain, or loose untwisted rope, and is bleached or dyed by means of a special plant which it is not necessary to describe. Having been so treated, the material is wound on to a beam shown in the machine illustrated in Fig. 212, which is provided with a special adjunct in a machine known as a holding back machine, by which the required tension is put on the thread. After being beamed for the second time the

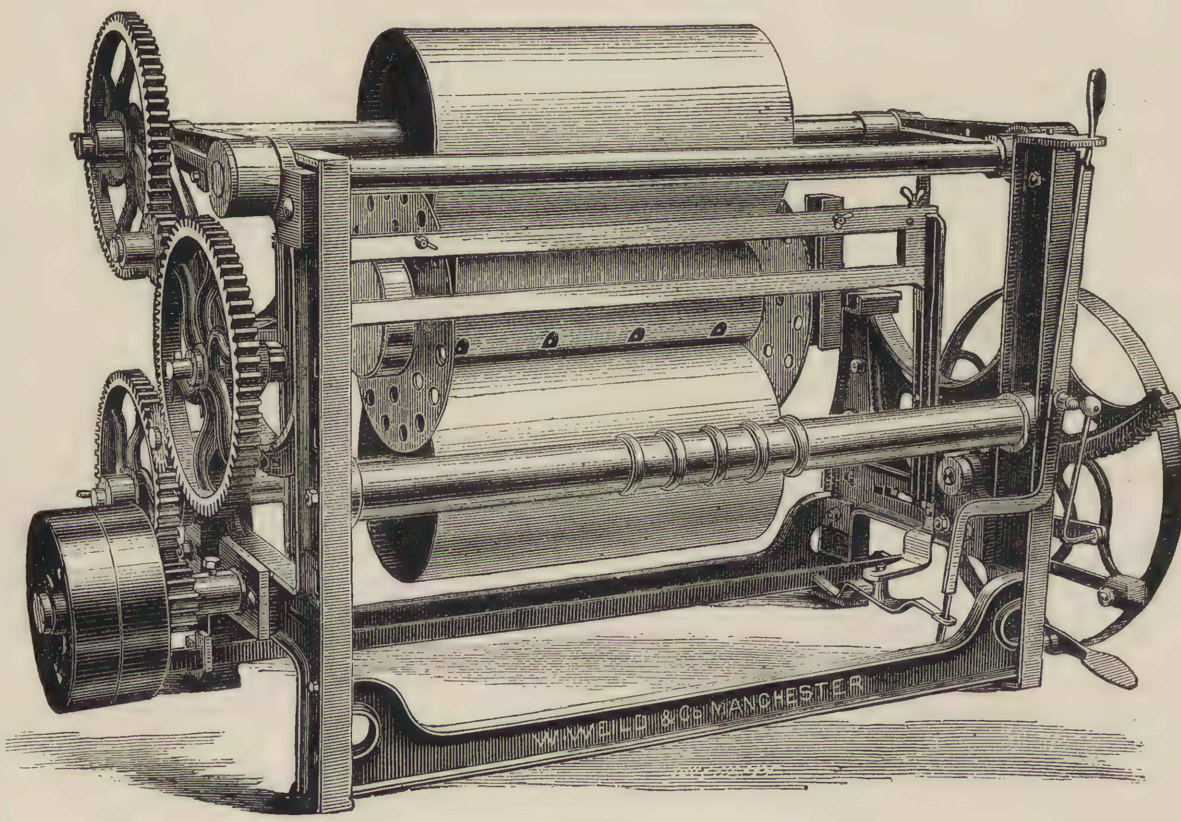


Fig. 212.

thread is passed through the machine shown in Fig. 213. The beam on which it has been wound is shown at the right hand side of this illustration, and contains, as stated, 360 threads. These are first taken through a size box, in which a pure size or starch is placed, and are then passed through the bristles of two cylindrical brushes. The brushes revolve at a high velocity, and thoroughly polish the thread without altering its shape, it being very desirable to preserve its rotundity. At the end of the machine, after being dried, the threads are wound on three brass beams, each divided equally by a central flange. 120 threads are wound on each beam, 60 of these being in each of the divisions. These beams

are placed, with the threads on them, contiguous to a special form of winding machine, where they are wound on to wooden spools or bobbins, each of which, when full, contains 1¼lb. of the finished threads. These are used to feed the spooling or balling machines afterwards described. In preparing soft thread—that is, unpolished thread—a similar procedure is followed, except that, after bleaching or dyeing, the threads, after being dried, are wound on to the second beaming machine. This system is—with special modifications adopted by various manufacturers—the one universally employed. The polishing machine will polish 120lbs. weight of 30's 3-cord thread in 10 hours, and soft thread can be produced in the same numbers at a rate of 5,670lbs. in 56 hours. The cost in wages of this system is much lower than that of the older method of hank polishing, in addition to which fewer knots are made in the thread, owing to the longer lengths treated continuously.

(403) When thread is finally produced, by the processes described, in a suitable condition for sale, it is necessary to form it into small reels or bobbins, or into balls, each containing from 100 to 500 yards. The reels on which thread is wound for sale to the consumer are small bobbins in which a short barrel is used, with a head or flange at each end. The flange is bevelled on its inner side, and the length of the opening between the flanges is greater at their peripheries than at their roots. The reels are filled with thread by the action of a machine of great ingenuity called the "spooling machine." This was originally invented by the late Mr. Wm. Wield, and is now made by his successors, Messrs. Shepherd and Ayrton. A perspective view of it is given in Fig. 214, and, as there shown, it has eight heads. The empty spools are placed in a trough, the mouth of which terminates immediately behind the winding head. The latter consists of two spindles which grip the spool in the centre, being formed conically at their extremities, so that they get a firm grip of the hole in the centre of the barrel. The operative mechanism in this machine is fixed in the double frame, or "headstock," shown at the right hand of the machine, and drives, by means of longitudinal shafts and wheels, the spindles of the whole of the heads. The thread is guided by steel guides, threaded on their underside to correspond with the pitch of the spirals formed by the thread, upon which during winding they rest. The guide rods, upon which the guides are fixed, receive an oscillatory movement after the reels are filled, so as to leave the space free for the removal and replacement of the spools. In addition to this they have a reciprocal horizontal traverse equal in length to the length of the spool, and gradually increasing as the surface upon which the thread is wound increases, owing to the bevel of the heads of the reels. This reciprocal movement is obtained from the revolution of a finely pitched screw on a roller, with which two half nuts alternately engage, one on each side of its centre. As these are thrown into gear they give a traverse to the guide rail in each direction, and it will be easily understood that the period of their engagement determines the length of the guide traverse. In commencing to wind a set of reels the first operation is to place them between the spindles. One reel falls out of each trough on to a plate, which rises so as to hold the reel or spool between the open spindles. The spindles close upon the spool, which immediately begins to revolve and draw thread from its bobbin, which, with its fellows, is held in a suitable creel. The thread is passed through a spring tension clip, which holds it sufficiently to keep it tight, and

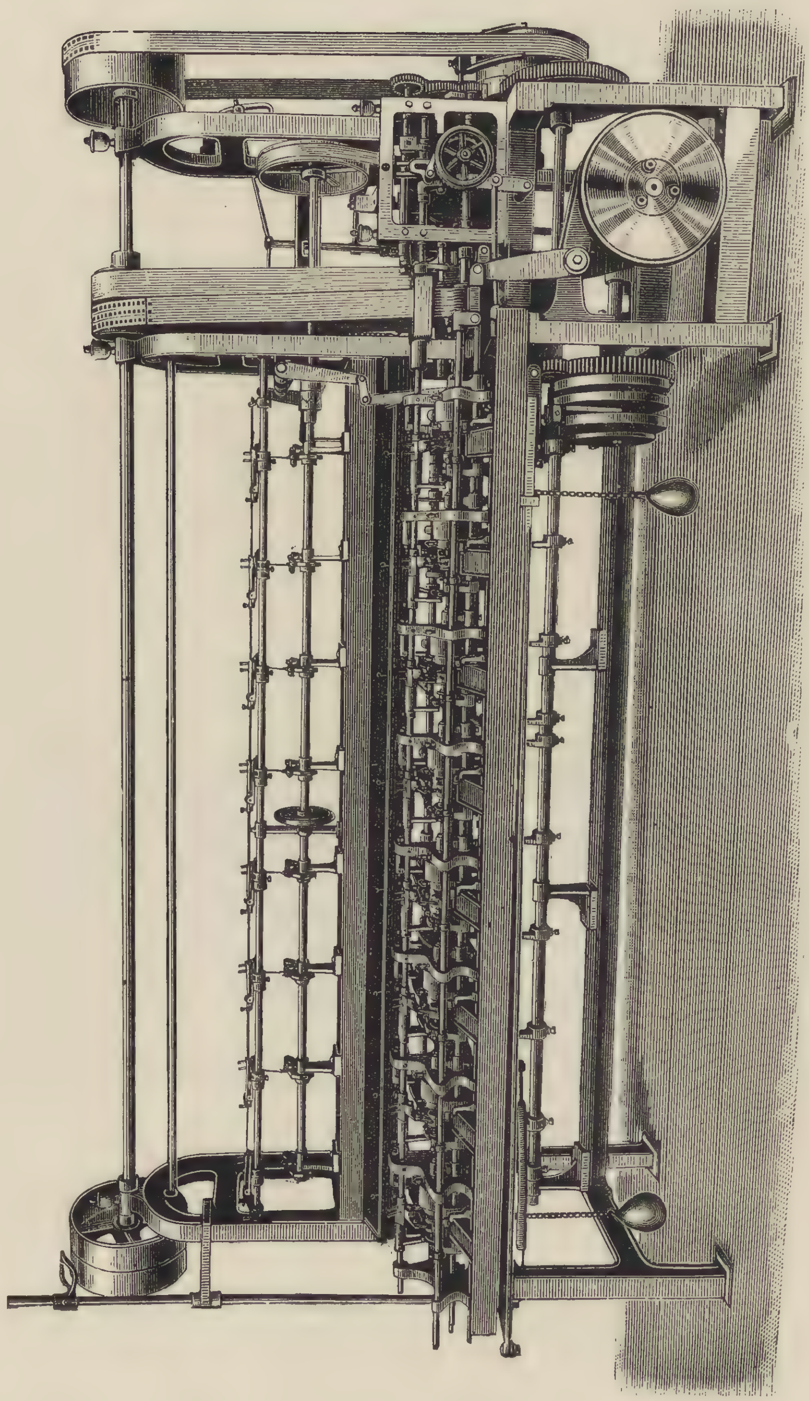


Fig. 214.

afterwards over the guide referred to. Winding goes on until the required definite length is wound on, when it automatically ceases. Immediately this occurs a knife placed in an arm descends and cuts a nick in one end of the spool, and the thread is drawn into this nick. In this way the end is secured, and, as soon as this is effected the thread is drawn over a knife and cut. The spindles then open and the spools fall down a shoot. Another set of spools is then fed, as described, and the ends of the thread are so held that, immediately the spindles begin to revolve, they are drawn on to the spools, winding thus beginning automatically. Owing to the perfect automaticity of the machine a high rate of speed is obtained, and 26 gross of spools, each containing 200 yards of thread, can be produced from a machine in $10\frac{1}{2}$ hours.

(404) There are spooling machines in which the operations of feeding and emptying the spools are carried out manually, but, as thread making is now mostly carried out in large establishments, their use is not great. In some cases, especially for "crochet" cottons, the thread is wound into balls. In this case it is wound on short cylinders, revolved at a slow speed, round which a flyer rotates. Through an eye in the flyer the yarn is passed, and is wound on to the cylinders by the superior speed of the flyers. To the former an alternate oscillating movement is given, by which the coils of thread are wound in coarse spirals. In the end a barrel shaped spool is formed. As a rule the "balling" machine is worked by hand, but a machine has been made by which the operation is nearly an automatic one. The use of balling machines is, however, limited, and there is not the necessity for an automatic machine, such as exists in spooling thread.

CHAPTER XIV.

MISCELLANEOUS MACHINES AND ACCESSORIES.

(405) It will be easily understood that there are a number of accessories required to complete the equipment of a mill before the machinery previously described can be fully utilised. It is neither necessary nor profitable to deal with the whole of these, but some of them may be advantageously described. Among the earliest needs in the process of spinning are the cans which are used for the reception of the sliver as it leaves the carding engine. These are made of tin sheets, which are rolled into short cylinders and soldered together, the various lengths being similarly connected. The cans are about 10 inches in diameter and 4 feet long, and are strengthened at the top and bottom by iron hoops. In spite of this precaution they are often bulged or dinted in consequence of the rough way in which they are handled. To obviate this defect Mr. Lang Bridge has for a few years past made the can with corrugations extending longitudinally of it, the additional strength thus given being advantageous without adding anything to the weight.

(406) The rollers used in the various operations of spinning and drawing are, as has been pointed out, mainly of two types. The lower lines are generally fluted and the upper lines smooth surfaced. The former are usually made of a fine grained iron, and the flutes are carefully made so as to be very smooth, their pitch depending upon the character of the work to be done. The lower lines of drawing rollers are, as was shown, continuous, and, it being manifestly impossible to make them in one length, they are jointed or coupled at suitable intervals. The coupling is made by forming the roller with a square nipple at one end and a correspondingly formed socket at the other. By fitting the nipple of one roller into the socket of the other a firm and perfect union is effected. The rollers are coupled, so that they are perfectly in line throughout, and when placed in the frame they revolve steadily. The top rollers, as previously shown, are formed in short lengths, and are smooth on their peripheries. In order to give a soft yet firm grip to the yarn, as it is delivered, it is customary to cover the top rollers with a sheath of woollen cloth and leather. This is in many cases done by hand, the cloth and leather being cut to length and formed into a sheath in this way, after which it is drawn on to the roller. Such a mode of procedure has all the defects of handwork, and a description of a complete set of machines made by Messrs. Dronsfield Brothers will not be without interest.

(407) The first of the series is shown in Fig. 215, and is employed to spread the paste upon the cloth. The cloth is fed from a roll, and can be delivered by a slight addition of mechanism in measured lengths. As it is drawn forward it passes through a paste box formed of sliding plates D, adjoining the spreading plate B. By means of the adjustable screw C the vertical position of the latter can be fixed so as to give

any amount of paste required. The cloth is cut into lengths and wrapped on the roller, to which it adheres, the joint being carefully made so as to leave no gap or thick place. After this surface is prepared and dried a leather sheath is drawn over it.

(408) The leather used for covering rollers is specially prepared from sheep skins, and is very thin and soft. It is carefully polished or glazed on one side, and must be free from any roughnesses or defects. In spite of all the care bestowed on their preparation, "roller skins" are often uneven in thickness, and in order to correct this fault, the machine shown in Fig. 216 is used. The skins are cut up by a special appliance into strips of the necessary width to cover the boss of the roller, and these are subjected to a grinding action on their unpolished side. The strips are held at one end by a clamp on the drum A, which is revolved slowly, and which can be set in as desired by the wheel F and screw. As the roller A revolves, it brings the skins in contact with a grinding roller B, covered with sand or glass paper. In this way the leather is ground down to one thickness throughout the strip, and the chance of unevenness in the roller is thus diminished. A fan is fixed to draw away the dust and deposit it in a suitable receptacle. After the strips

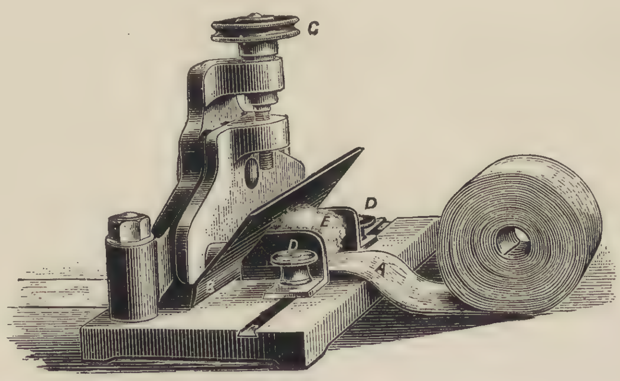


Fig. 215.

are so ground, they are passed to a splicing machine—that is, a machine in which they are cut to the necessary length to form a sheath. The edges in this operation are bevelled, so that in overlapping no thick place is formed. The splicing machine in its complete form is shown in Fig. 217. The leather strip A is placed on the table face up, and is carried forward by the feed rollers B. The extent of the roller traverse is determined by the position of a stop D, which limits the oscillatory motion of a double clip handle C. This is made in two parts, like a pair of tongs, each end being centred on the spindle on which the wheel M is placed. By squeezing the handle together M is gripped and can be rotated. The handle C is ordinarily in the position shown, and, when it is moved forward while gripping the wheel, it carries the latter with it until the stop D is reached, when the motion ceases. Thus any length of leather can be fed by one stroke of the handle. When the leather is fed the pressing bars F are brought on to it, and the knife K held in the frame H at a suitable angle is also brought into position. H slides on a cross surface prepared for it, and by drawing it across the leather while held in position, the latter is cut to the required bevel, which remains constant throughout the whole of the working of the machine.

(409) When the short lengths of leather are obtained, they are cemented along their bevelled edges with a special cement, and are firmly pressed together by a light screw press. In this way a sheath is formed large enough to draw over the boss of the roller, but a little longer than it. The covering so formed is then pulled over the roller by the machine shown in Fig. 218, which is the type commonly used, however the covering is prepared. The leather tubes are placed upon the spring A, consisting of a thin cylinder of sheet metal, which is divided into several ribs as shown. The roller to be covered is placed end up on the

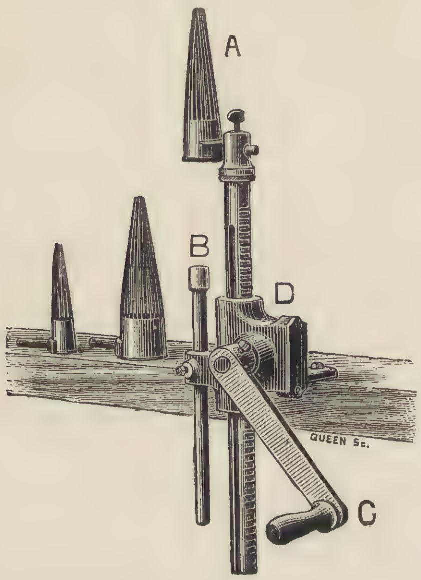


Fig. 218.

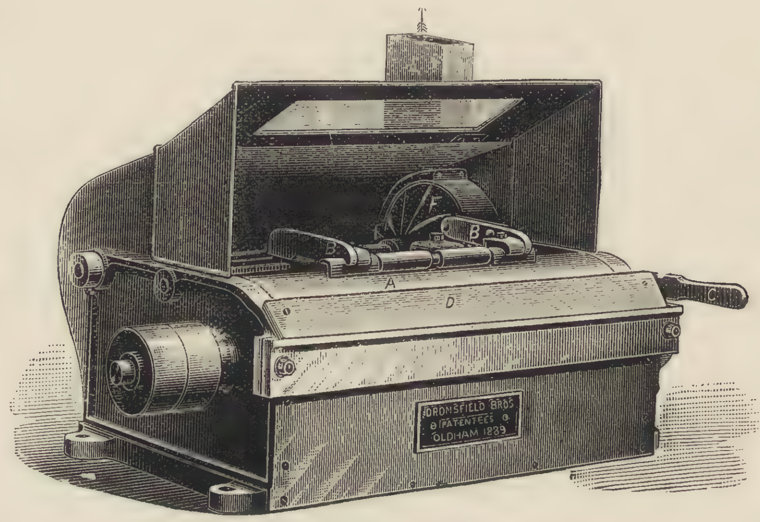


Fig. 219.

recessed stop B, and by a revolution of the handle C the spring is drawn over the roller leaving the sheath behind it. The special construction of the spring enables it to pass over the boss of the roller and draw out of the leather tube. A small portion of the tube projects beyond the boss at each end, and this it is necessary to wrap over so as to firmly secure the covering. This operation is effected by placing the roller in suitable holders, and subjecting the projecting ends of the tube to an end pressure. For this purpose the rollers are revolved by being brought into frictional contact with a rotating cylinder. The most complete machine for this purpose is shown in Fig. 219. The rollers are held in arms B B on the cylinder A, the bearings or steps in the arms being specially constructed, so as to provide a very thin surface to sustain the roller. The ends of the leather being cemented, they are turned over by means of a rod or bar, and are thus perfectly secured. A fan F is placed under the hood of the machine, and takes away any fumes produced by the process of ending. The cylinder is made of thin steel, and is run at from 700 to 1,000 revolutions per minute.

(410) Having covered the rollers they are subjected to a rolling pressure, so as to render them perfectly cylindrical. The machine shown in Fig. 220 is a special one of Messrs. Dronsfield Brothers, and consists of a

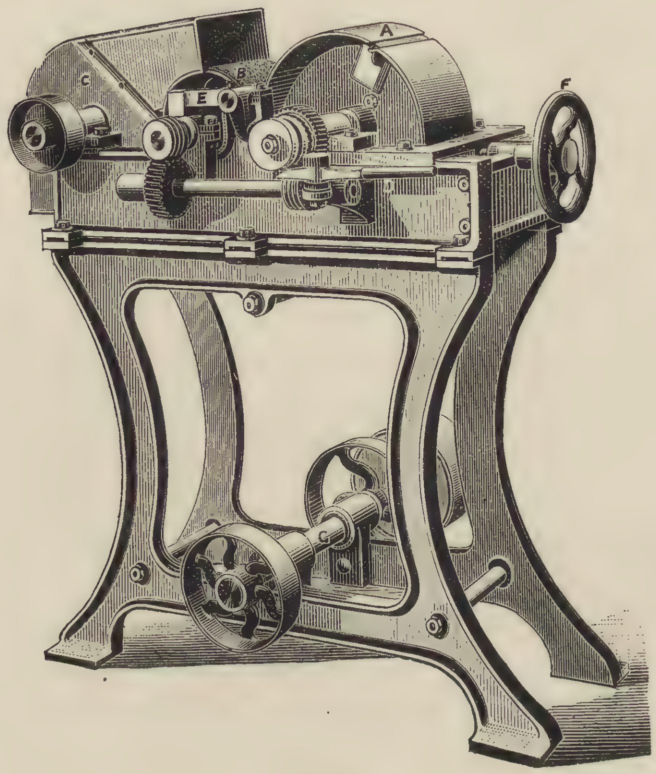


Fig. 216.

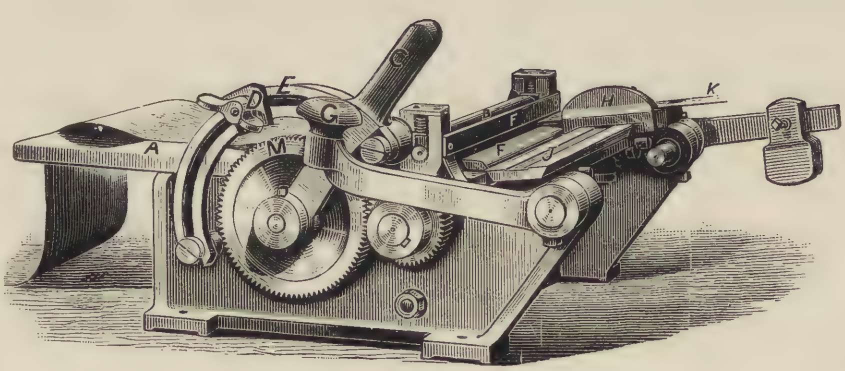


Fig. 217.

steam chest to which steam is admitted. The upper side of the chest is planed so as to be quite true, and upon it the rollers are placed. Above the steam chest a table or plate A is imposed, having a reciprocal motion to and fro over the steam chest, derived from the cranks N. Four rollers are fed at one time, and after being subjected to the action of the pressure plate during four of its double movements, are delivered at the other end of the machine. Owing to the heat of the surface on which they are rolled, and the peculiar movement given to them, the rollers emerge in a truly cylindrical form. Ten rollers can be thus rolled per minute, and no difficulty is experienced in attending to the machine. It is, of course, essential that there should be no unevenness of the rollers, and the treatment accorded them by the series of machines described ensures this being avoided.

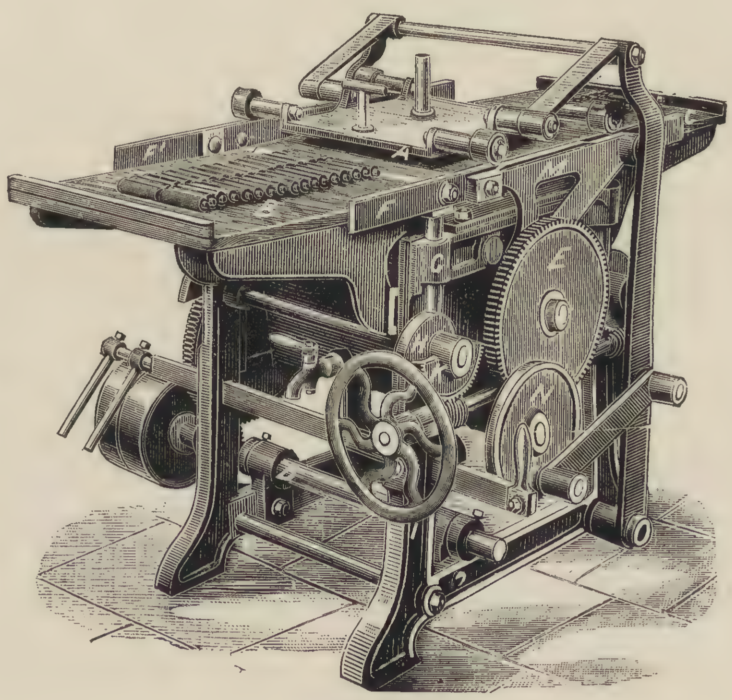


FIG. 220.

(411) It is sometimes the practice to grind the leather covered rollers so as to remove any flats formed during working. Messrs. John Hetherington and Sons make a machine for this purpose. By it the rollers, while held in suitable bearings, are subjected to the action of a revolving grinding disc, covered with glass paper, which traverses the whole surface of the roller and grinds it up perfectly true. The rollers so produced are quite cylindrical, and a large number of the machines are in use.

(412) The bobbins which are used in the various machines employed are made of specially selected timber, which is kept in stock until it is thoroughly well seasoned. The bobbins are carefully turned, and are smoothly finished on their surface, so that the cotton does not adhere to them when it is wound upon

them. Their shape and general construction is well shown in Fig. 221. In this A B and C represent various types of roving bobbins, spools, or "tubes," these being drawn from samples supplied by Messrs. Wilson Brothers, Limited. The tubes are shown of three designs. The one shown at A is single ended—that is, can only be used one end up. In the foot of the tube—which is enlarged—four notches are cut which engage with the projections on the top of the driving bevel pinion described in Chapter X., by means of which it is positively driven. A similar construction is shown in C, but this is a shorter tube, suitable for a roving frame, where the lift is less than that of the slubbing frame. B is double ended, and can be used either end up, as desired. It will be noticed that all these tubes are shelled out internally, so as to be very light, and they are so constructed at the top that they fit easily upon the spindle or collar. In this way, while they are steadily held, they can slide without undue friction, which is a somewhat important point. The bosses of the tubes, as shown, are hooped with metal rings or shields. The object of this is to protect them from damage when, after doffing, they are placed upon the spindles, this operation being often very roughly carried out. The tubes are, as stated in Chapters X. and XI., placed in the creels of the roving frames, mule and ring frames, on "skewers," the construction of which is shown at D and E, These are made of ash usually, and are finely pointed, so as to revolve easily and freely.

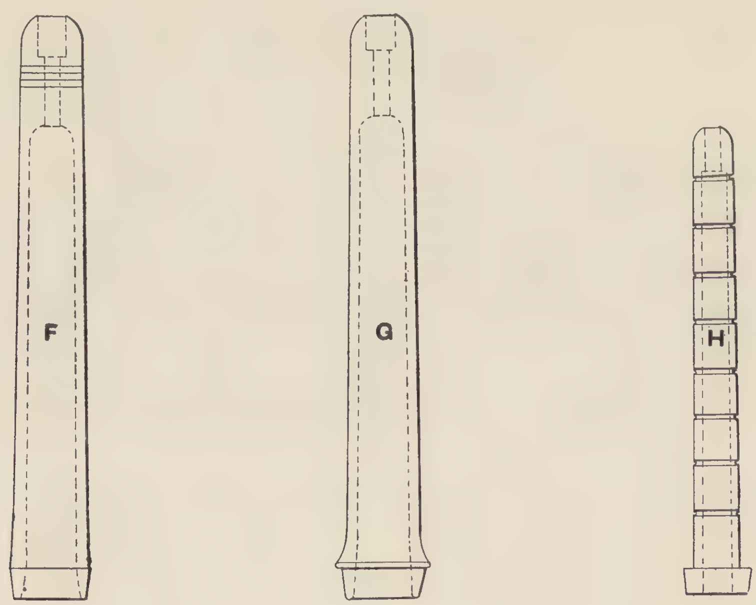


Fig. 222.

(413) Bobbins for ring frames are made as shown in F, G and H (Fig. 222). The forms illustrated in F and G are intended for use with Rabbeth spindles, and that marked G is hooped at its lower end for the reasons indicated in the previous paragraph. The bobbin or spool H is used for spinning weft on ring frames, and is much smaller than the type employed for twist yarn. It is a common practice to fit shields to all kinds of bobbins, several makers doing so in one form or another. A special form of ring bobbin is made by

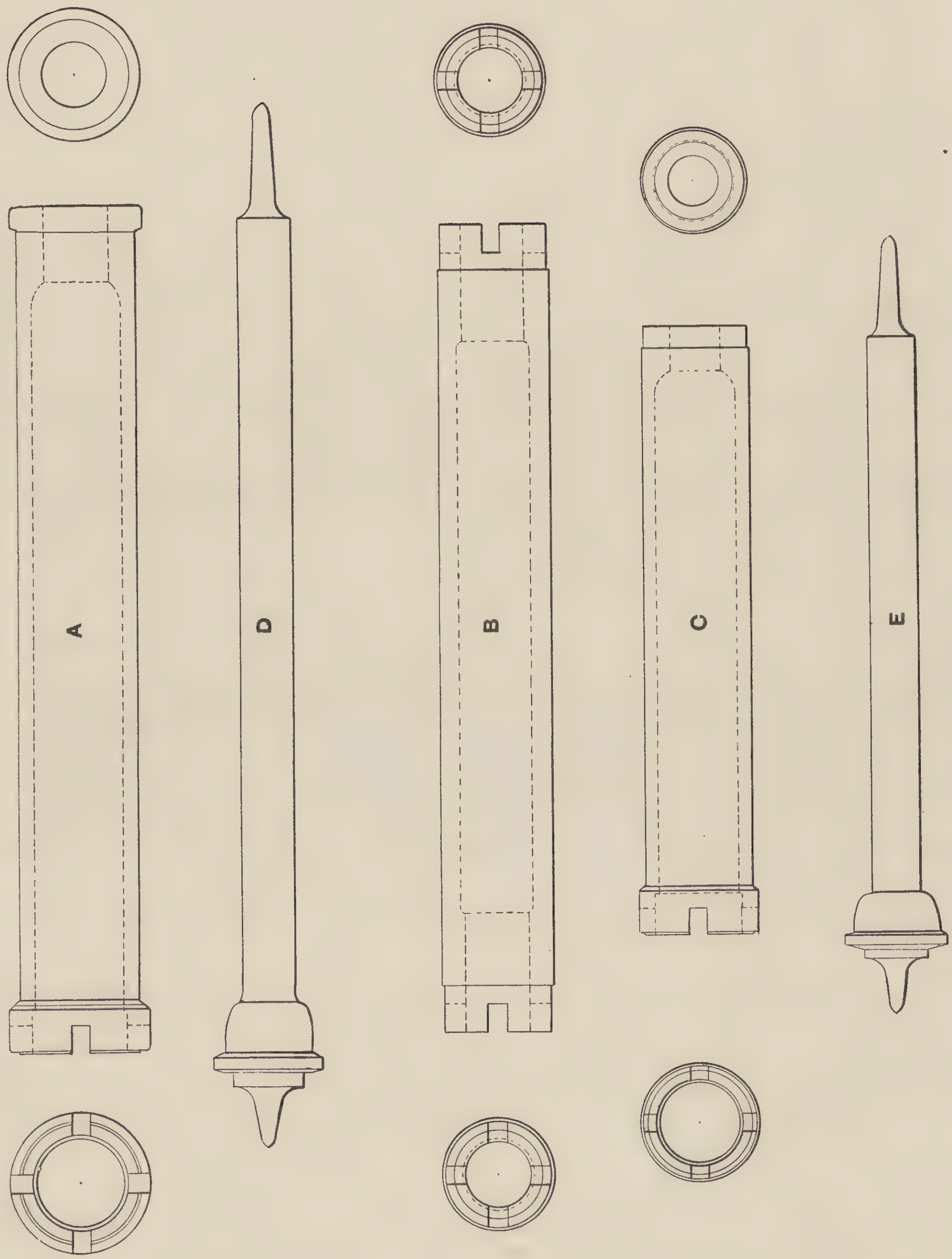


Fig. 221.

Messrs. Wilson Brothers, of Barnsley, in which the grip at the foot is entirely done away with. The bobbin is a double flanged one, something like the type shown by the letter I, but has a projecting lower boss or nipple which loosely fits the spindle cup. This is the invention of Mr. W. R. Sidebottom, of Stockport, and at the time of writing it is undergoing an extensive trial. So far as this has gone the results are favourable, and no loss of twist has been detected although the grip contact does not exist. The bobbin shown by the letter I (Fig. 223), is the form employed for doubling purposes on ring frames, and is driven by the slot shown in the detached plan view. The bobbin L is the form used on throstle spinning frames, as adapted for long collars, somewhat resembling in principle the Mason collar described in Chapter X.

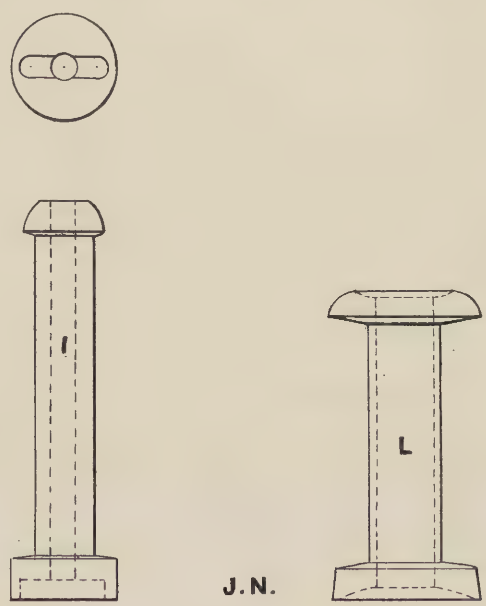


FIG. 223.

(414) An important improvement in ring bobbins has been recently adopted by Messrs. Wilson Brothers, Limited. This is a mode of enamelling or coating them with a composition which is entirely impervious to damp. The plan is an American one, but a series of tests made by the author show that bobbins treated in this way can be subjected to the action of hot or cold water or oil without being in the least affected. It is a very usual practice in preparing yarns for weaving purposes to "condition" them—that is, to allow them to absorb a certain amount of moisture. This is often done while they are wound on the spool or bobbin, and the result is that the latter speedily lose their form and become out of balance. By coating them as described this evil is avoided, and yarn can be conditioned with impunity while on the bobbins.

(415) In order to ascertain the counts of yarn, a machine known as a "wrap reel" is employed. This consists of a small fly or swift similar in form to the swift employed in the reels described in the last chapter, but smaller. This is revolved by a sun and planet arrangement of wheels which is, in principle,

like the differential motion described in Chapter X. A short hank of yarn—one lea or 120 yards—is wound on the wrap reel, the time when the exact length is wound being denoted by the sounding of a bell, when, as the winding is a manual operation, the machine can be stopped. The hank so formed is taken off the reel and weighed, and the weight of a full hank can thus be easily ascertained. By the aid of a table the counts of any of the short hanks wrapped can be easily ascertained. By means of a small machine, the strength of the yarn can be tested, the pull upon it being obtained by a weighted arm. An indicating apparatus is provided, by which the weight of the pull is registered.

(416) During the past few years one or two simple graduated indicators or scales have been introduced, by which the weight of a piece of cloth can be readily obtained. One of these, "Staub's," has been introduced into this country by Messrs. George Thomas and Co., and by its aid the counts of either the

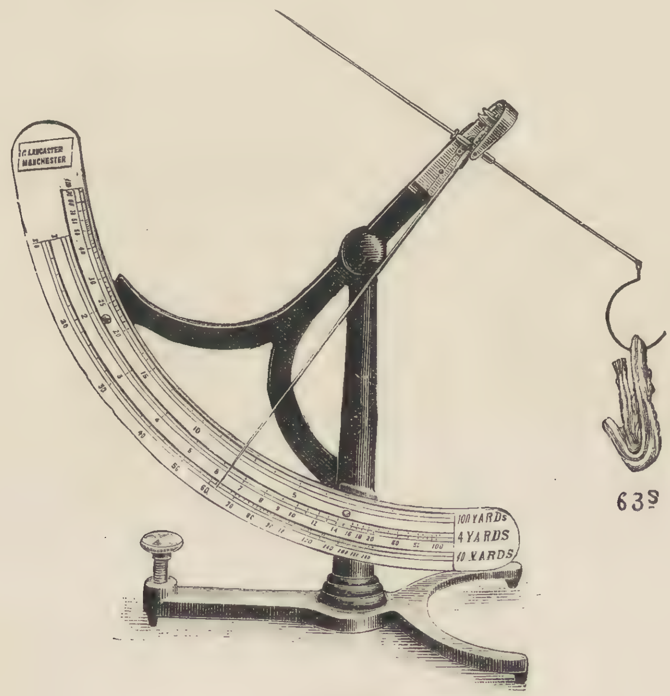


Fig. 224.

warp or weft in a piece of cloth can be readily ascertained. It differs in form from the scale shown in Fig. 224, but is based upon the same principles. In the form shown in Fig. 224—which is Niess' scale, and is controlled in England by Mr. Charles Lancaster—a light hinged arm is formed at one end with a hook, on which a length of 40 yards of yarn can be hung. This causes the arm to be depressed, and a pointer finger traverses the face of a graduated quadrant, a glance at which is sufficient to show the counts of yarn. These yarn balance are simple and reliable, and are being used in increasing numbers,

(417) It is customary to fit to spinning machines indicators by which the production is registered. One or two of these, as made by Messrs. G. Orme and Co., are described, but it may be as well to say in passing that

these appliances are largely used, and are very instrumental in preventing disputes as to the remuneration of the operatives in cases where this is determined by the work done. The indicators are attached to the back shaft, and can be made in two forms, either to indicate the number of hanks produced in thousands, or the number of draws made. The first is shown in Fig. 225, the second in Fig. 226, and the details of the mechanism in Figs. 227 and 228. Referring to the latter, an arm B is fixed on a shaft, forming a centre for it, being constructed with two points C and D, acting as catches. On the shaft on which B is centred is a sector A, gearing with a worm on the back shaft. As was pointed out in Chapter X, the back shaft makes an equal number of revolutions in each direction at each draw, so that the sector is caused to oscillate, and partially rotate the shaft. In this way the arm B is also oscillated in the same direction as the sector. The triangular-shaped surface E is fastened on its shaft, and the point D, on the arm B, comes in contact with the notch shown in E, when the end of B is being raised. Thus E is rotated, and when B is reversed as

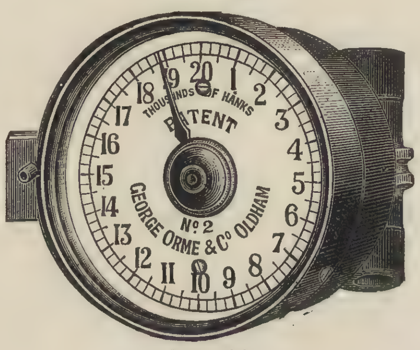


Fig. 225.

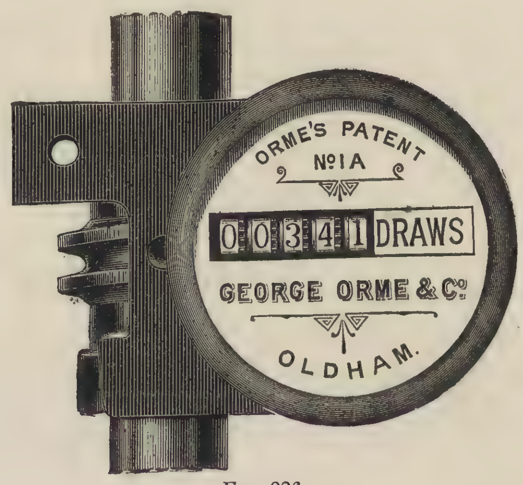


Fig. 226.

described, the point C engages with E, and continues its rotation. While this is occurring the other end of B is descending, so as to assume a position to act on the next point of the triangle. The rotation of E is therefore continuous, and it makes a complete revolution every three draws. On the triangular wheel E is a flange or disc F, in which is secured a pin G. The wheel M is fixed in the position shown, and is constructed with fourteen teeth, half of which are the full width of M, the other half being only half that width, but are a little longer. As F revolves the pin G comes in contact with one of the long teeth in M, and moves it forward. If the disc F were quite circular the overlapping of the broad teeth, as a reference to Fig. 228 will show, would prevent any movement of M. A notch H is therefore cut in the disc, so that only when one of the broad teeth is opposite the notch can any motion of M take place. The motion of M is thus prevented from taking place except when required, and is communicated to the finger of the indicator by the gearing shown. From this description it will be noticed that there are seven operating and seven locking teeth in the wheel M, and in arranging the gearing this fact is considered.

The figures on the dial represent thousands of hanks, the number being arrived at from a calculation based on the number of spindles and the length of draw of the mule. Where required to meet special local cases, the indicator can be arranged to indicate the number of draws made by the mule. In Figs. 229 and 230 the indicator used for slubbing, roving, and drawing frames is shown. Instead of using a graduated

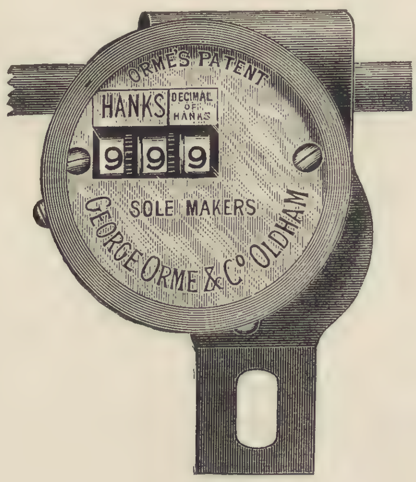


FIG. 229.

dial and finger the figures are arranged on discs, of which there are three, one disc registering the decimal part of the hanks passed. The worm shown in Fig. 230 is driven by direct attachment to the front roller. The three discs are driven from one another, there being a very similar locking motion to that described in

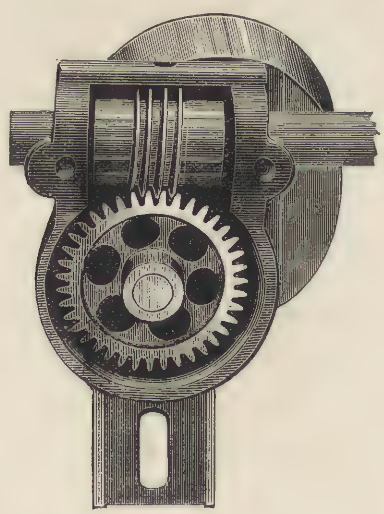


FIG. 230.

connection with the mule indicator. The effect of this arrangement is that the first disc has to make a complete revolution before the second is moved one figure. When the second has completed its revolution it in turn moves the third. The discs are locked after each movement, so that until again unlocked no

motion can occur. The indicator is arranged to indicate up to 100 hanks, with decimal parts of each hank. Owing to their special construction no fly can enter the working parts, although there is easy access to them.

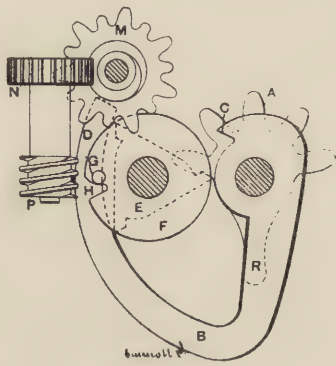


Fig. 227.

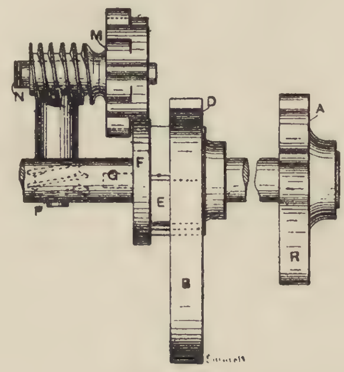


Fig. 228.

(418) It was stated in Chapter XI. that it was customary to paste or starch the bottoms of cops, in order to render them adhesive and to stiffen them. Usually the starch used is carried about in buckets, and the method is both dirty and wasteful. Mr. Lang Bridge makes the apparatus shown in Fig. 231, which

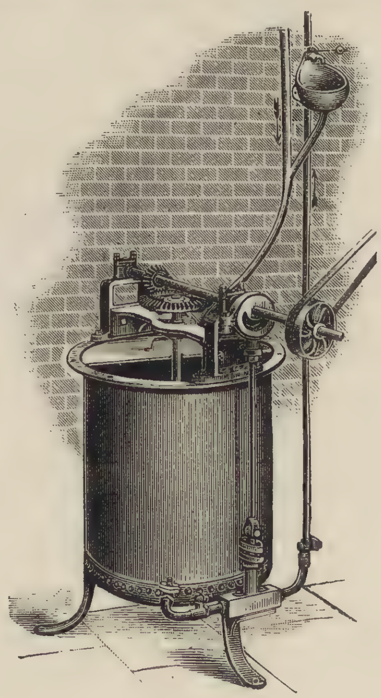


Fig. 231.

consists of a copper pan in which the starch is boiled, and round the inside of which a copper steam coil is placed. An agitator or dasher is constantly revolved in the manner shown, and a small gun metal pump is driven from the same shaft. By a system of pipes the starch is raised to the various mule rooms, and is

discharged over enamelled basins placed as shown, the orifice of the pipes being closed by a self-closing tap. The spinner can at any time get a supply of starch, and any surplus returns by gravitation to the mixing tank, where it is again used up. It is obvious that this method possesses many advantages over the crude mode previously described.

(419) In concluding these pages the author is fully conscious of many shortcomings, which are inevitable in a task of this magnitude, but he believes that something has been done to formulate present knowledge and practice. Many things could be added, but the intention with which the book was commenced has been carried out, and it is confidently believed that the information given and the treatment accorded to the various machines will be found of value to many students. Any suggestions of improvements or enlargements will be gratefully received, so as to enable future issues to be more valuable and useful.

APPENDIX.

Description of the Arrangement of Machinery in the Mill of the Standard Spinning Company, Limited, Rochdale.

It will be interesting to many persons to have some particulars of the arrangement of one of the most recently constructed Lancashire mills. The Standard Spinning Company's mill is not only one of the latest but also one of the largest yet built. It consists of five floors and a basement. Each of the main rooms is 250 feet long by 125 feet wide, and adjoining the building on the ground floor is a shed 240 feet long by 40 feet wide, in which most of the cards are placed. The remaining four floors contain the mules Placed a little apart from the main building is the scutching or blowing room, which is 70 feet by 60 feet, and has placed above it two mixing rooms. The general arrangements are shown in Fig. 232, which is a plan of the ground floor, showing the arrangement of the machinery.

Referring now to that figure, and dealing first with the mixing and scutching arrangements, the former are shown in the small detached drawing. The arrangement of mixtures and cross lattices is well shown. The three longitudinal lattices shown convey the cotton to the mixing bin, the cross lattice receiving it from the bale breaker, which is placed in the room above. There are four porcupine feed tables employed, each with an extra length of lattice, which deliver the cotton into the dust trunks, by which it is conveyed to the openers fixed in the ground floor room. Of the opening machines there are four, each of which is fed by its special tube or trunk, as clearly shown. The openers are provided with lap attachments, so that the cotton is formed into that shape at as early a point as possible. Adjoining the openers, with their feed end close to the lap machine, six scutching machines with single beaters are placed. These are fed with three laps, and the cotton is, after being treated by them, again formed into laps, which are fed to the six finisher scutchers placed immediately behind the first six. The finishing machines are fed with four laps each the doubling being considerable. It will be noticed that the whole of the arrangements are made so that the cotton moves steadily forward without much handling. In this respect the design is admirable, and this part of the work has been carried out by Messrs. Lord Brothers.

The carding machines are of the revolving flat type, made by Messrs. John Hetherington and Sons. There are in actual use 128, and each is made with a cylinder 50 inches diameter, being fed from 40-inch laps. The drawing frames adjoin the carding engines, as shown, and are nine in number, each machine having four heads with seven deliveries each, the latter being indicated by the thick black dots. These machines supply drawn slivers to twelve slubbing machines, fitted with long collars, and each containing 90

spindles, their lift being 10 inches. The gauge of these machines is four spindles in 19 inches. The slubbing frames can be distinguished by the dotted lines behind them, which represent the position of the cans, and each of them is fed by the drawing machines placed relatively to them as shown by the curved arrows. It will be noticed that the same readiness of access has been kept in view as in the case of the scutching machines, and the necessary carriage of the cans is reduced to a minimum. In addition to the slubbing frames there are 18 intermediate frames, each containing 132 spindles of 10-inch lift and a gauge of six spindles in 19½ inches. The equipment of this room is completed by 52 roving machines of 168 spindles each, 7-inch lift, and a gauge of eight spindles in 20½ inches. The whole of the drawing and roving machines are made by Mr. John Mason, and the latter are fitted throughout with Mason's long collars. Before leaving this department a few words may be said about the driving. The machinery is driven from a second motion shaft, driven by ropes from the engine, the engine house and rope race being indicated in the drawing. The carding machines are driven by counter-shafts from the line shaft shown, as are also the drawing frames. The roving machinery, on the contrary, is all directly driven from the line shafts, two of which are specially arranged for the purpose, as clearly shown. The belts are long and have a half twist, but the advantages of direct driving are so great that this slight disadvantage is not worth taking into account.

The mules are of an improved Parr-Curtis type, made by Messrs. Taylor, Lang, and Co., Limited. They are almost equally divided between twist and weft mules. Of the former there are 44 in all, each of which is made of a spindle guage of 1⅜ inch. Half of them contain 1,038, and the other half 1,044 spindles each, in all 45,804 twist spindles. There are also 44 mules for weft, the guage of the spindles being 1⅛ inch. Twenty-two of these contain 1,260 and twenty-two 1,272 spindles each respectively, giving a total of 55,704 weft spindles. The total number of spindles, therefore, in the mill is 101,508. The numbers spun are from 40's to 50's twist, and 50's to 70's weft.

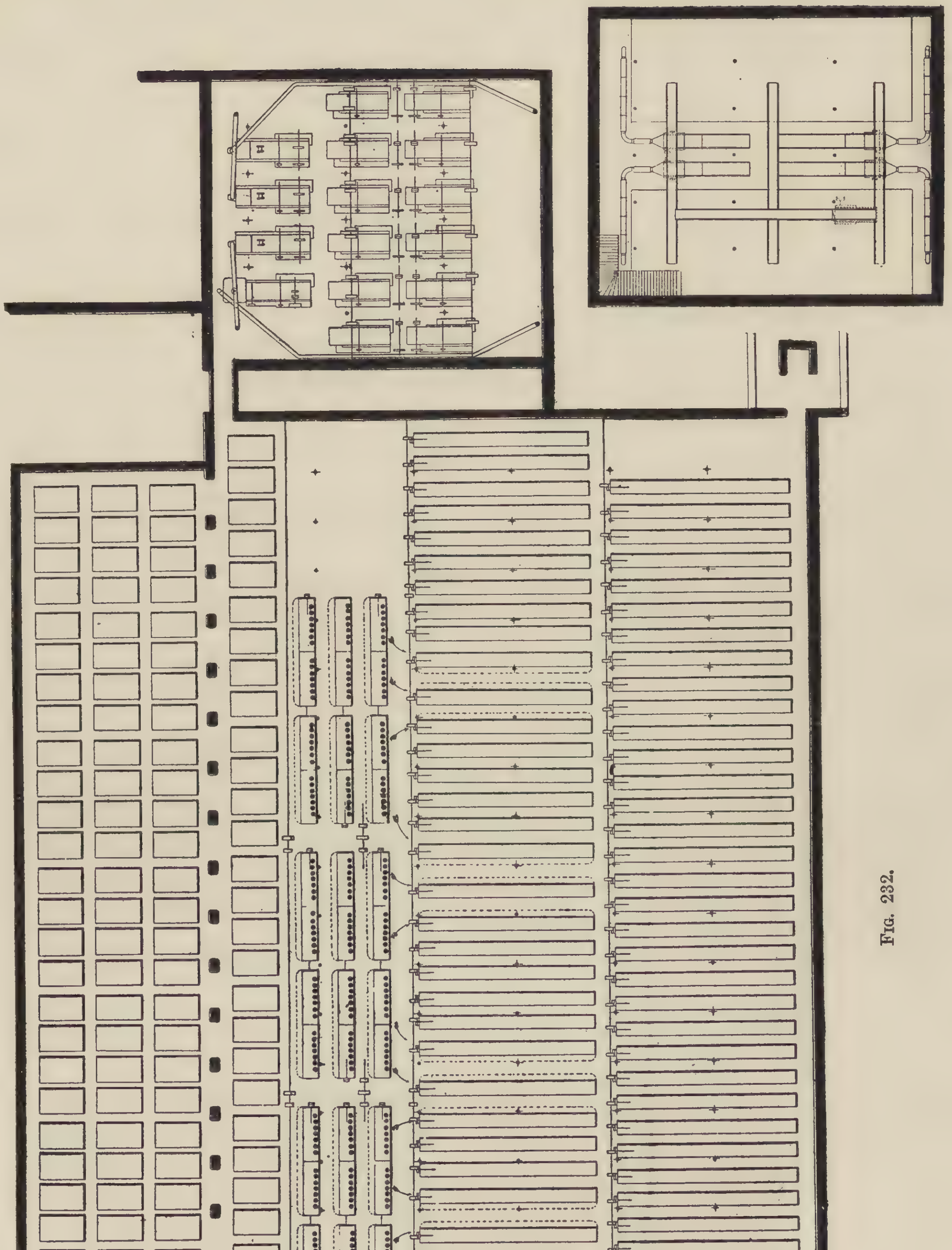


Fig. 232.

LIST OF ILLUSTRATIONS.

NOTE.—In order to facilitate reference to the illustrations, they have been so placed as to be easily found, without turning back. It has not, however, always been possible to place them in consecutive and proper order. To preserve the sequence, they are numbered in the order in which they are referred to in the text, although—especially in Chapter XI.—they are sometimes referred to in paragraphs widely apart.

GLOSSARY.

Changes. In a mule the alteration of the motion of the various parts at the end of the outward and inward runs.

Chase. The extent of the traverse of the winding faller wire.

Cop. The spool of yarn formed on a mule.

Counts. The number of hanks of yarn in one pound weight.

Creel. A frame in which feed bobbins are placed.

Doffer. In carding, the drum removing the fleece from the cylinder; the person removing bobbins or cops from the spindles.

Doffing. The process of removing finished material from the machines.

Doubling. The combination of two or more laps, slivers, or threads; as a separate process the twisting together of strands of yarn.

Draught. The amount of attenuation of a lap or sliver.

Draw. The longitudinal traverse of a mule carriage.

Droppings. The impurities removed from cotton during opening or scutching.

End. One strand of sliver, roving, or yarn.

Fillet. A narrow strip of cloth.

Fly. The loose short fibres given off during spinning.

Gauge. The distance from centre to centre of spindles or rollers.

Governing. The regulation of the traverse of the quadrant nut.

Halching. The entanglement of the coils of yarn at a cop nose.

Hank. A length of 840 yards of yarn.

Lap. A rolled fleece of cotton.

Lea. One seventh of a complete hank.

Lead. The excess of the revolution of a bobbin, flyer, or traveller over each other.

Licking. The adhesion of cotton fibres to any surface.

Lift. The extent of the traverse of a guide eye or bobbin.

Motes. Fragments of broken seed or leaf.

Neps. Small knots or tangles of fibres.

Nose. The extreme upper point of a cop.

Piecing. The union of two ends of sliver, roving, or yarn.

Poker. The vertical rod sustaining a bobbin or ring rail.

Roller Laps. Coils of roving or yarn wrapped on rollers after breakage.

Roving. The attenuated and partially twisted sliver.

Selvedge. The edge of a lap or sliver.

Shaper. The mechanism by which the shape of a cop is determined.

Single. A length of sliver, roving, or yarn in which only one strand exists.

Skeining. The process of winding yarn into hanks.

Sliver. The attenuated fleece of cotton from carding or combing machine.

Slubbing. The sliver after having passed through the first roving machine.

Slubs. Thick pieces of cotton attached to or twisted into the yarn, caused by accumulation of fly.

Snarls. Small twisted loops of yarn.

Staple. The length of individual fibres in any grade of cotton.

Stretch. The longitudinal traverse of a mule carriage.

Stripping. Removing the imbedded impurities from card clothing.

Twist. The number of turns per inch in a thread or yarn; yarn used for warps.

Warp. Yarn forming the longitudinal threads in cloth.

Weft. Yarn forming the transverse threads in cloth.

Yarn. The fully twisted roving.

GENERAL INDEX.

A

B

D

E

F

G

H

N

O

P

Q

R

T

U

V

W

Y

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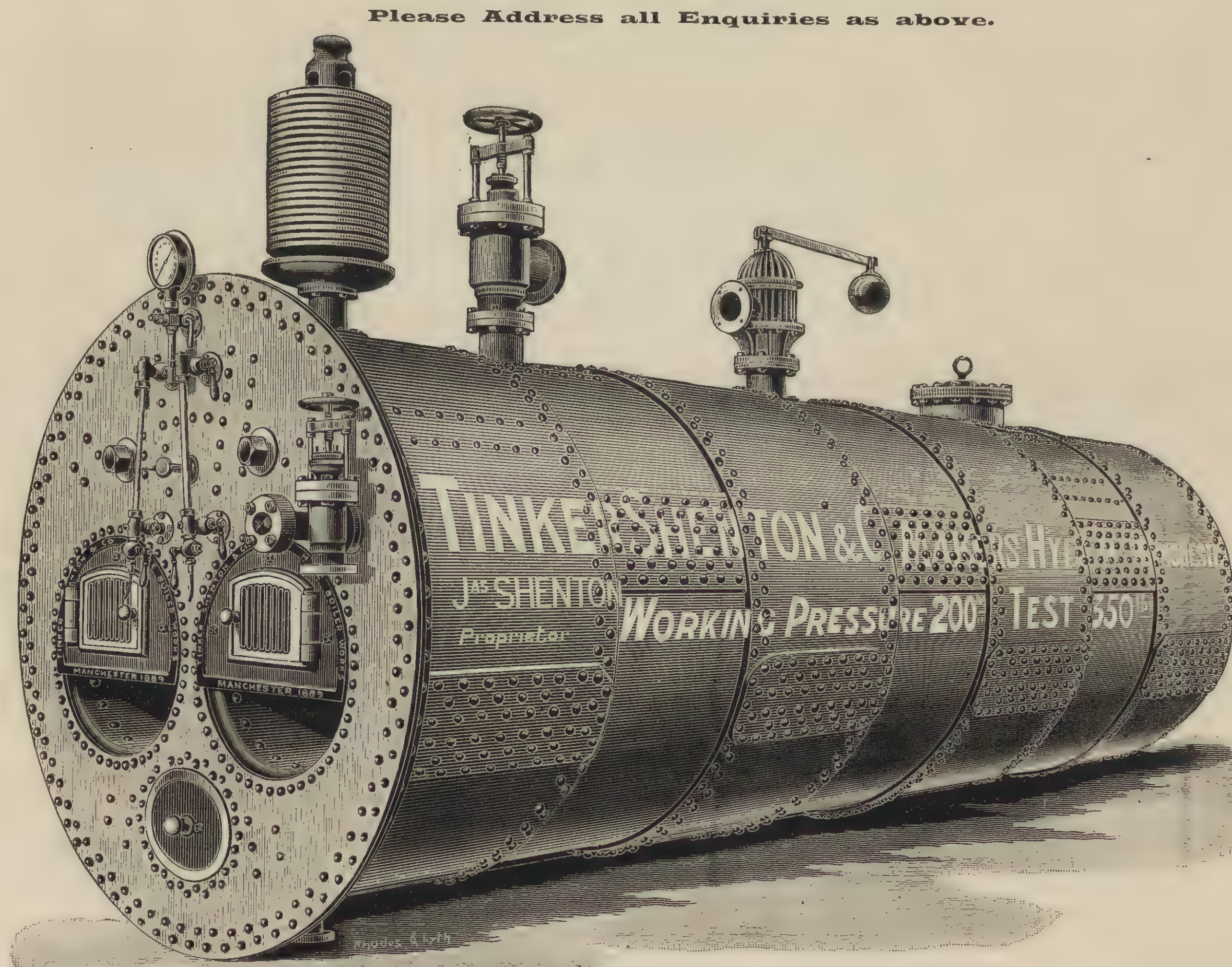
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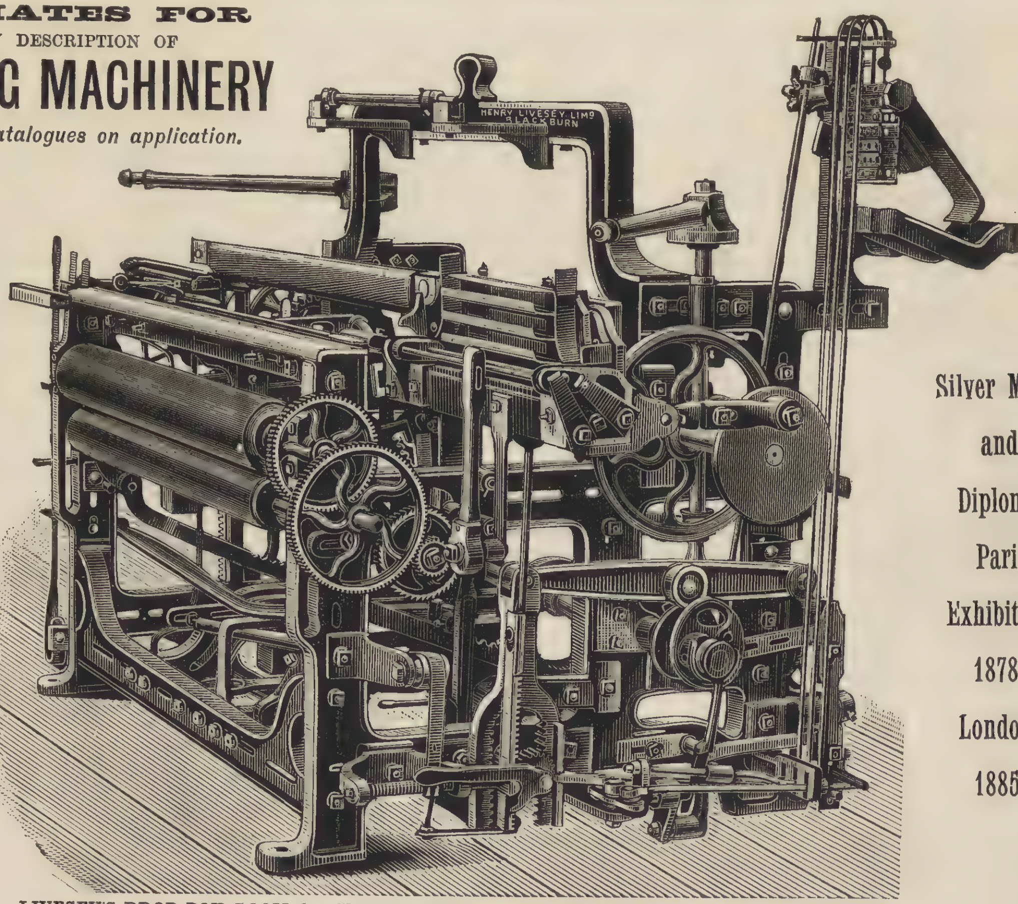

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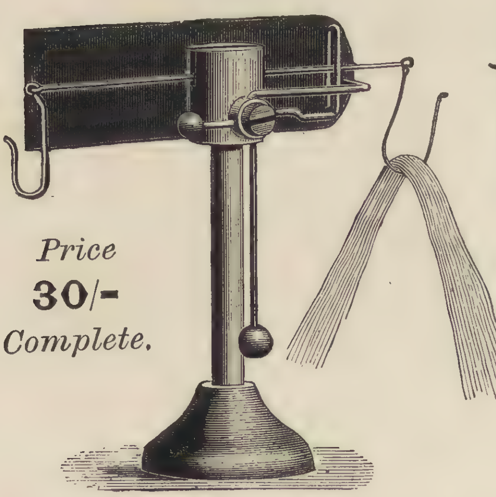

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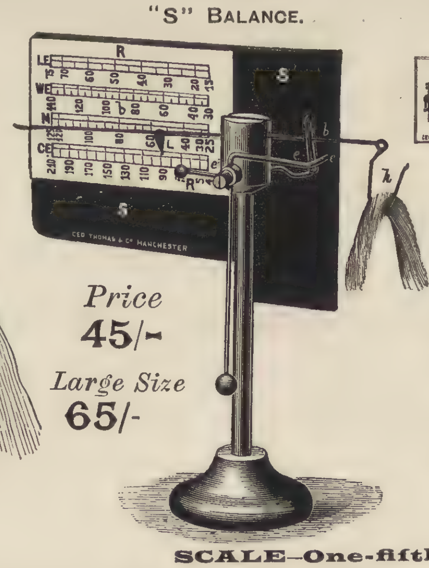

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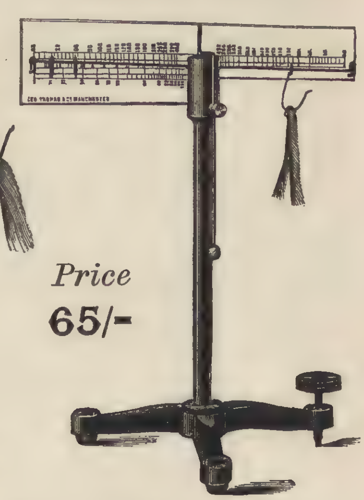

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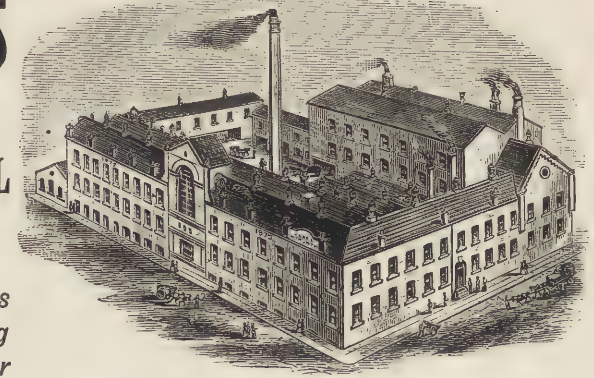

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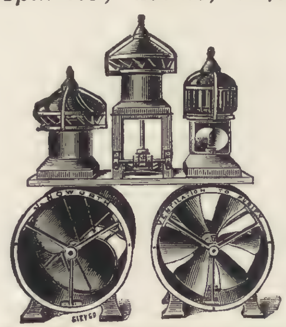

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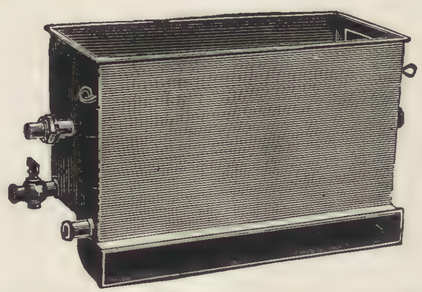

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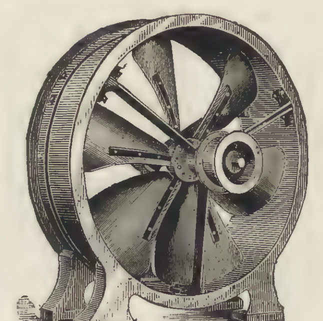

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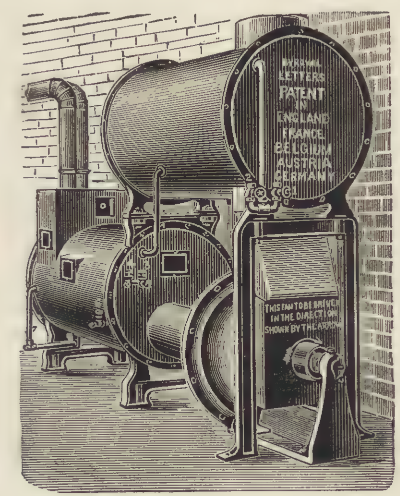

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